OPERATOR'S INSTRUCTION BOOK

CINCINNATI

No. 2
CUTTER and TOOL GRINDER

INCLUDING MACHINES HAVING
POWER TABLE TRAVERSE

★

Publication No. M-1951-2

This Booklet should be Filed in the Tool Crib and Issued by Tool Check only

MILLING MACHINE DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI, OHIO 45209

THIS booklet gives, in a condensed form, tables and data which are necessary to set up and grind all the ordinary types of milling cutters on the CINCINNATI® No. 2 Cutter and Tool Grinder. Of course, a wide variety of small tool room work can also be economically and accurately ground with the aid of the standard attachments. Detail instructions for the operation, lubrication and adjustment of the machine are given to help the new operator to understand more fully the operation and care of his machine.

At the time of writing, this booklet was completely up to date. However, due to continual improvements in design, it is possible that descriptions contained herein may vary slightly from the machine delivered to you. This merely implies that the machine has been improved to better fulfill your requirements.

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ILLUSTRATION REFERENCE NUMBERS

For your convenience in quickly finding illustrations referred to in the text, we have given all illustrations the same number as the page on which they appear. For example, Figures 27A, 27B, and 27C are all on page 27.

SERIAL NUMBER

The serial number is stamped on the front of the bed below the name CINCINNATI.

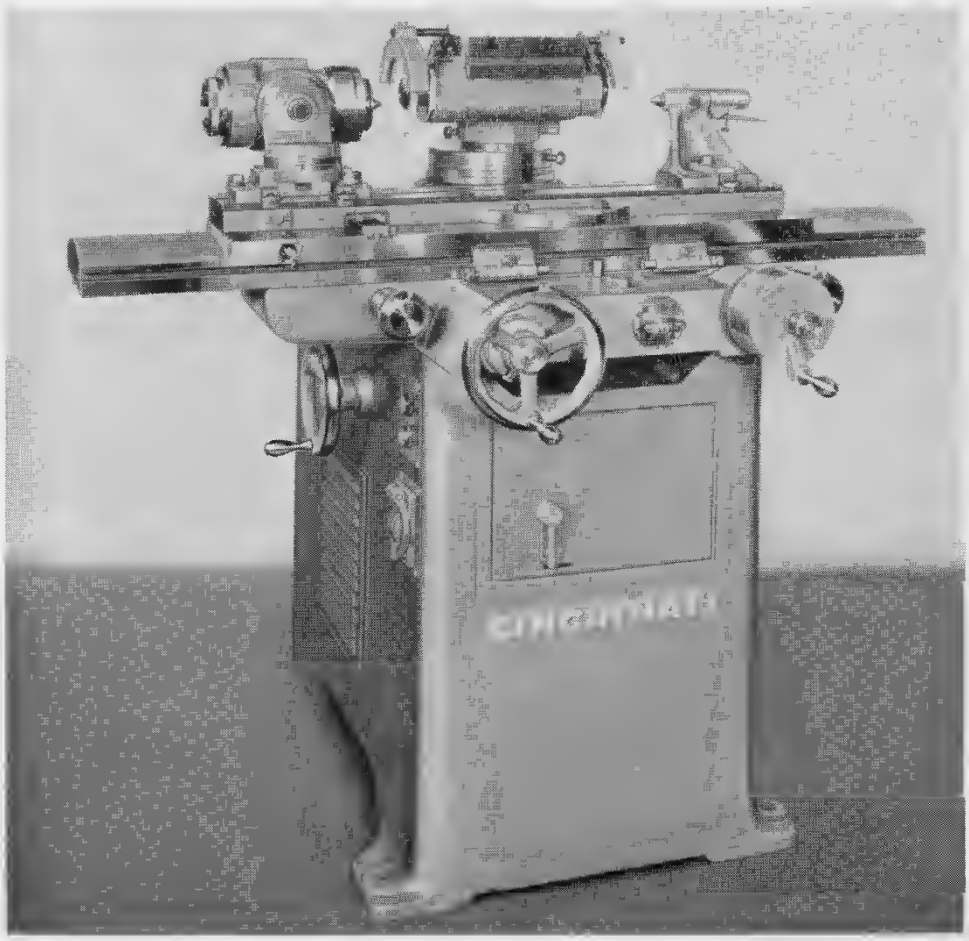


Figure 3A
CINCINNATI No. 2
Cutter and Tool Grinder

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

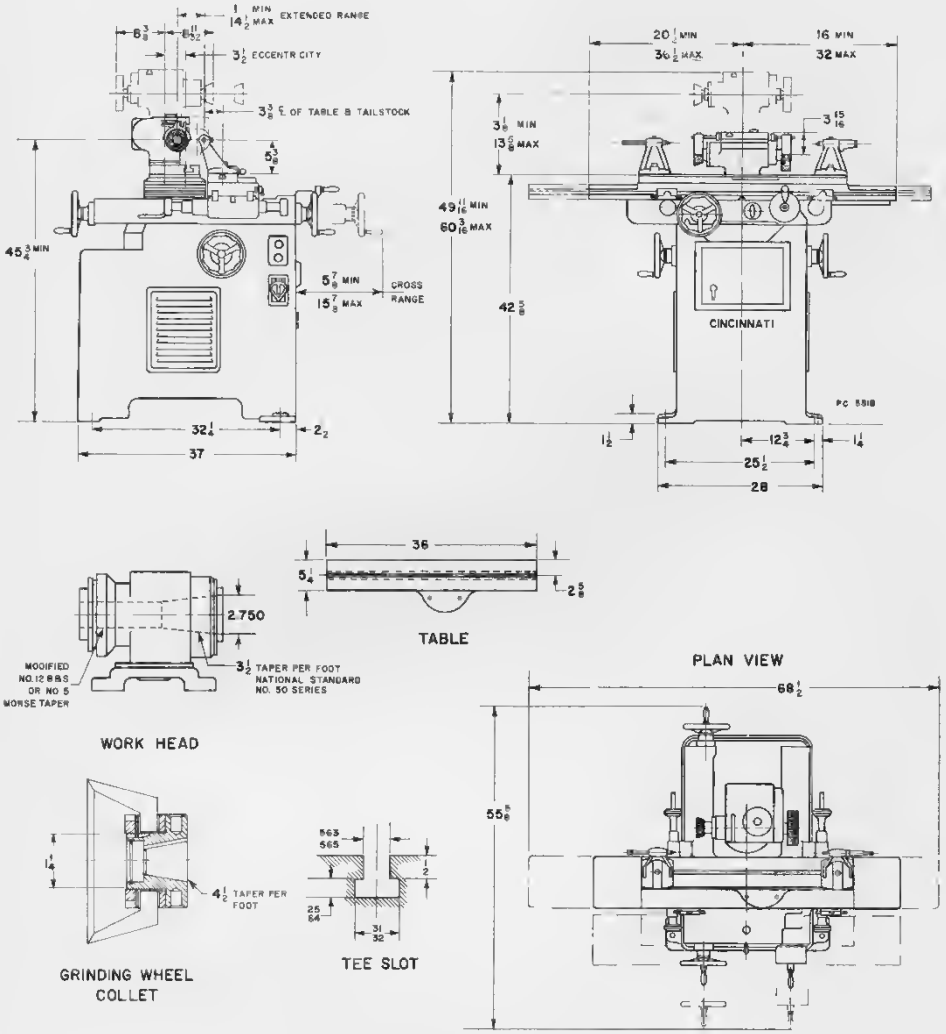
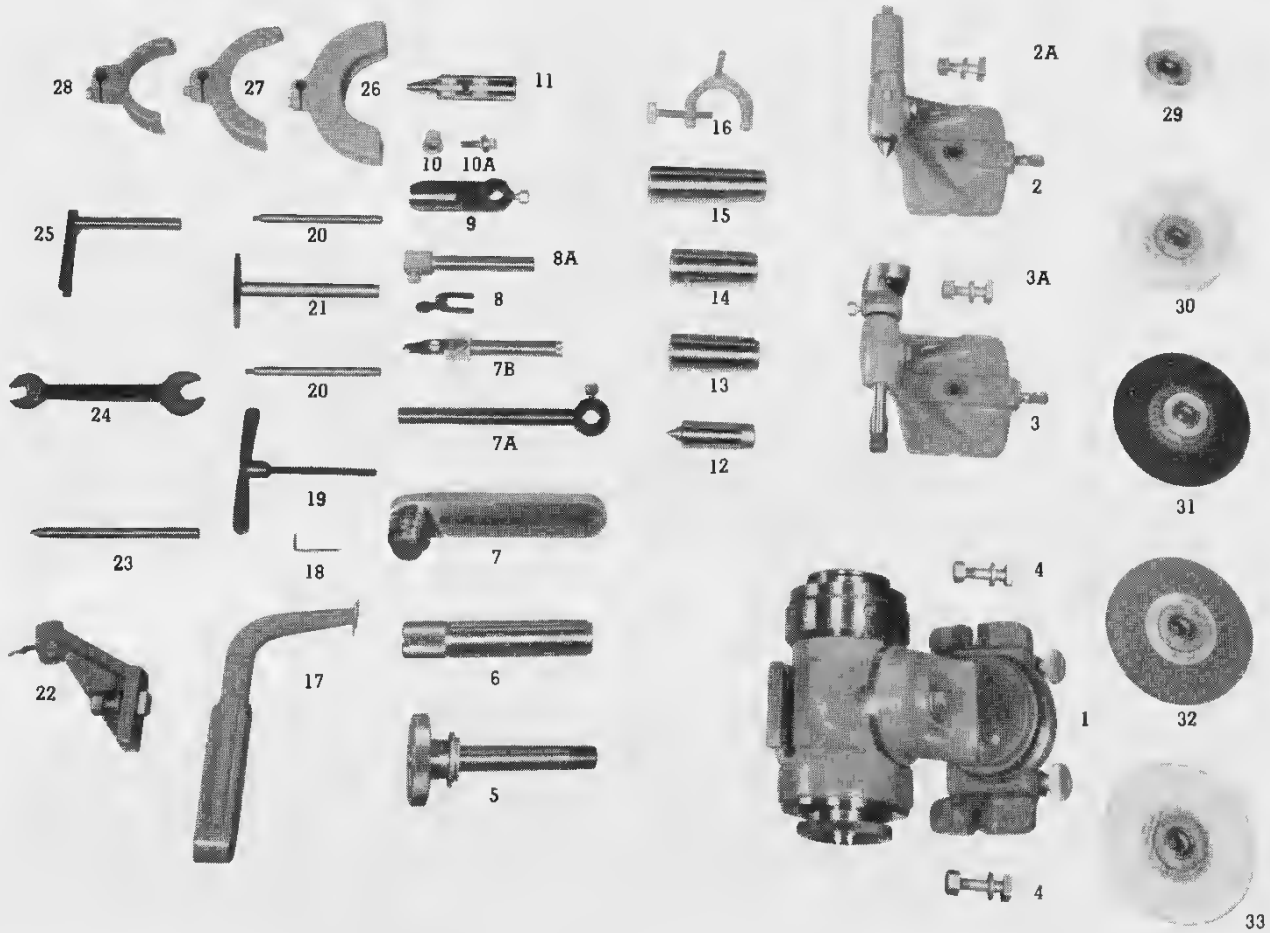


Figure 6A
Dimensional Drawing

GENERAL SPECIFICATIONS

CAPACITY		
Swing over Table		10½″ Diameter
Length, between Right and Left-hand Tailstocks		27″
Length, between Tailstock and Workhead		21½″
Face Mills on Workhead		10″ Diameter
Saws on Table		48″ Diameter
Formed Cutters (using 6″ Wheel)		5½″ Diameter
TAPER HOLE IN WORKHEAD SPINDLE	One End	No. 12 B & S or No. 5 Morse
	Other End	No. 50 Series National Standard
TABLE		
T-Slots (Number and Size)		One .563″/.565″
Working Surface		5¼″ x 36″
RANGE		
Longitudinal Movement of Table		16″
Cross Movement of Table		10″
Cross Range Gained by Wheelhead Eccentricity		3½″
Cross Range Gained by Swivel Table		3½″
Total Extended Cross Range		17″
Table Swivels		180°
SWIVEL TABLE ADJUSTMENTS: (Taper Per Ft. on Diam.)		
Tange-Bar Taper Setting Device	Toward Wheelhead	5″
	Away from Wheelhead	5″
Fine Taper Setting Device	Toward Wheelhead	2″
	Away from Wheelhead	2″
Table Graduations in Center, in degrees		90°
Vertical Movement of Grinding Wheel Spindle		10½″
Swivel Movement of Grinding Wheel Spindle		360°
Maximum Distance Centerline Spindle to Top of Table		13⅝″
GRINDING WHEEL SPINDLE SPEEDS (Two)		6530 rpm
		3890 rpm
GRINDING WHEEL SURFACE SPEEDS	6″ Diam. Wheel	6110 fpm
	3½″ Diam. Wheel	5985 fpm
FLOOR SPACE FOR OPERATING		56½″ x 68½″
SHIPPING DATA		
Net Weight (approximately)	Plain	2050
	Universal	2250
Shipping Weight, Domestic	Plain	2430
	Universal	2600
Shipping Weight, Export	Plain	2500
	Universal	2750
Size of Case, Export	Plain	65″ x 57″ x 60″
	Universal	66″ x 72″ x 60″
Volume of Case, Export		171 cu. ft.
CODE NAME	Plain	NOTWO
	Universal	NOTAU

STANDARD EQUIPMENT
Supplied with Plain and Universal Machines



STANDARD EQUIPMENT—Plain and Universal Machines

Key No.	Item
1	Workhead.
2	Right-hand Tailstock.
2A	T-Bolt for Tailstock.
3	Left-hand Tailstock.
3A	T-Bolt for Tailstock.
4	T-Bolts for Workhead.
5	Draw-in Bolt and Washer.
6	Ejector Rod.
7	Extention Plate, Eye Bolt and Ring.
7A	Blade Holder Extension.
7B	Micrometer Tooth Rest Support with Round Top Blade (Item Nos. 7, 7A and 7B constitute Universal Tooth Rest Plate).
8	Offset Blade.
8A	Plain Tooth Rest Holder.
9	Plain Tooth Rest Plate.
10	Nut for Attaching Plain Tooth Rest Plate to Universal Tooth Rest.
10A	Screw for Item 10.
11	Wheel Spindle Extension, 2″ Long for 1¼″ diameter hole wheels.
12	*Work Center for Workhead Spindle.
13	*Reducing Collet—12 to 9 B. & S. or 5 to 3 Morse Taper.
14	*Reducing Collet—12 to 7 B. & S. or 5 to 2 Morse Taper
15	*Reducing Collet—12 to 10 B & S or 5 to 4 Morse Taper.
16	Clearance Angle Setting Dog.
17	Center Gage.
18	Wrench for Socket Head Screw.
19	T-Wrench for Grinding Wheel Collet Lock Screw
20	Two Pin Wrenches.
21	Collet Wrench
22	Diamond Bracket
23	Diamond Holder with Diamond
24	Double End Wrench (7/8″ and 9/16″ Openings)
25	Short Holder for Wheel Guard
26	Wheel Guard for Wheel Print Nos. 12Y-155, 1Y and 1Y.
27	Wheel Guard for Wheel Print No. 6Y-112
28	Wheel Guard for Wheel Print No. 11Y-120.
29	Grinding Wheel and Collet Assembly Print No. 11Y-120–3½″ x 1½″ x 1¼″ Hole–Flaring Cup.
30	Grinding Wheel and Collet Assembly. Print No. 6Y-112–5″ x 1½″ x 1¼″ Hole–Straight Cup.
31	Grinding Wheel and Collet Assembly Print No 1Y–6″ x ⅛″ x 1¼″ Hole–Straight.
32	Grinding Wheel and Collet Assembly. Print No. 1Y–6″ x ½″ x 1¼″ Hole–Straight.
33	Grinding Wheel and Collet Assembly Print No 12Y-155–6″ x ¾″ x 1¼″ Hole–Dished
	Universal Machines also include Four Attachments: (1) Cylindrical Grinding (2) Surface Grinding (3) Internal Grinding (4) Gear Cutter Sharpening See pages 116-122 for extra cost equipment.

Notes—*Your selection of taper hole in workhead spindle governs which set of reducing collets and work center are supplied. Collets, Key Nos. 13, 14, and 15 are interchangeable with the Standard Workhead and the present design of the No. 1 Radius Grinding Attachment, having a spindle bore opening of 1.776″, cannot be used on the No. 1 Radius Grinding Attachment having a spindle bore opening of 1.797″.

INSTALLATION INSTRUCTIONS

Before lifting the machine, be sure to swivel the eccentric wheelhead to the extreme back position as shown in Figure 10A, move the saddle toward the spindle as far as possible to avoid damage by interference with the rope and tighten the hand screw clamps (Figure 18B) to lock table slide in position. Do not lift this machine by a rope slung around the saddle. The cables or ropes used in lifting the machine should be capable of withstanding a weight of about 3000 pounds. Machines having power table traverse are lifted in the same manner.

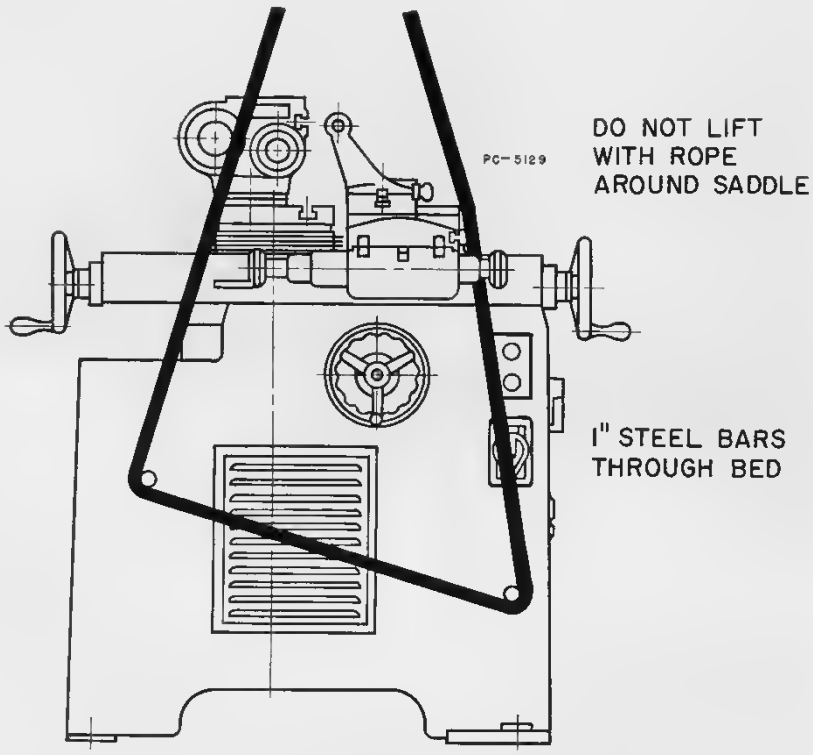


Figure 10A
Lifting a CINCINNATI No. 2 Cutter and Tool Grinder

Foundation. A special foundation is not required. Any substantial floor, wood or concrete, fairly flat, and sufficiently heavy to withstand the weight of the machine, will be satisfactory. However, do not locate the machine close to vibrating equipment, as vibration transmitted to the machine will result in a poor finish on the cutting edge of the cutter being sharpened.

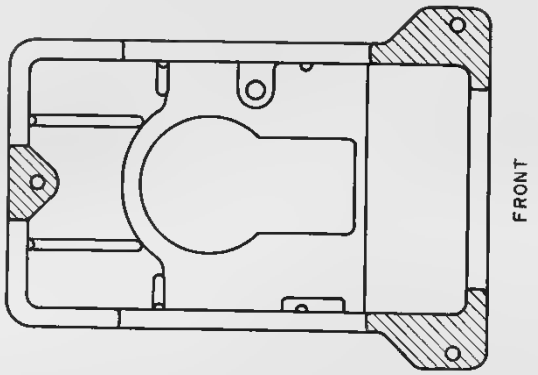


Figure 11A
Areas on Underside of Base in Contact with Floor

The effects of a vibrating foundation may be reduced or entirely eliminated by mounting the machine on a rubber base $\frac{3}{8}''$ or $\frac{1}{2}''$ thick. This base may be made by placing a good grade of oil proof sheet rubber between two thin steel sheets. Of course, the rubber selected should have sufficient unit strength to withstand the weight of the machine, which may be as much as 3000 pounds with fixtures. There are three bearing pads under the machine contacting the floor, indicated in Figure 11A.

Leveling. After the machine has been moved to its proper location, it must be carefully leveled. Use an accurate micrometer level for the operation. A carpenter's level or the bulb in a machinist's combination square is not good enough. Place laminated shims under the bearing pads of the base, alternating metal and felt shims, until the table is level in both directions. Shims should be large enough so entire bearing pad, under the base, is resting on the shim, so as to evenly distribute the weight of the machine. It is necessary, that the machine table and leveling instrument be absolutely clean and free of burrs to obtain the most accurate results.

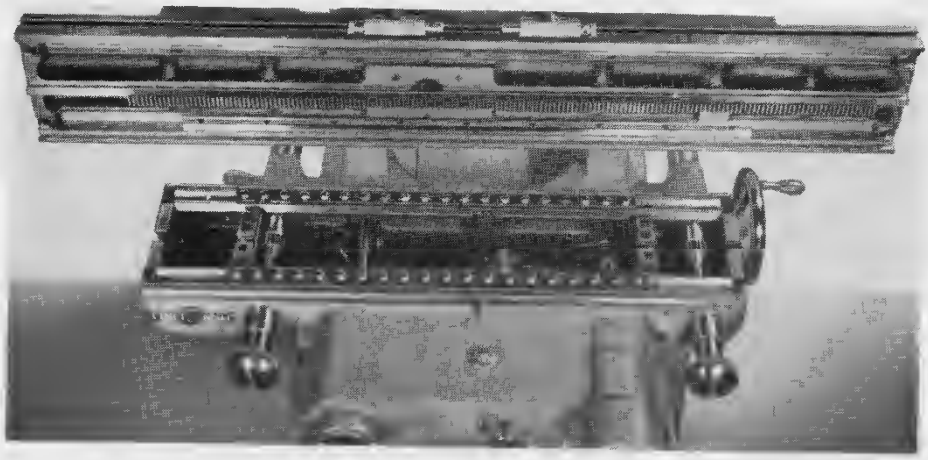


Figure 12A
Table Slide Ways

Assembling the Table and Table Slide. When you receive a CINCINNATI No. 2 Cutter and Tool Grinder, the table and slide will have been removed as a unit. Before replacing this unit, carefully wash the ways and balls with naphtha, and dry with a cloth having no lint. Do not oil them, unless the air is exceptionally humid. Sufficient lubrication can be obtained by dusting the balls lightly with graphite dust.

There are two ways in which the table unit can be replaced. After placing the balls in the cages and with the two bumper blocks removed from the left-hand end of the slide, support the table unit with a crane, or on a bed-high box, and carefully slide it on the ways far enough to fasten left-hand bumper blocks in position.

Another method would be, after the balls and cages are in place, remove all four bumpers blocks, two on either end of the slide, place the table directly on the ways, push the table first in one direction far enough to fasten bumper blocks in place, repeating the process, only in the opposite direction to fasten the other two bumper blocks in position.

Caution: Push table unit slowly over ways to avoid damage to ends of ball cages.

LUBRICATION

The lubricants recommended in the table on page 15 have been selected for their adaptability to a specific job. Use oils having the specifications indicated, and apply as directed.

Absence of oiling devices on the wheelhead indicates that the FILMATIC spindle bearings are automatically lubricated by the ever circulating spindle oil, necessary with these bearings, thus eliminating any further attention. Do not attempt to add any oiling devices.

Absence of oiling devices on the wheelhead indicates that the Anti-Friction Spindle Bearings are grease packed and lubricated for life, and requires no attention. *Do not attempt to add oiling devices to grease packed spindles.* The design is not suitable for oil; it will thin the grease to a fluid condition; it may run out the ends of the spindle to the wheels.

The table slide rides on precision steel balls, which are separated by a flat cage. Ball tracks under the table slide and on top of the saddle are made of hardened steel, ground in position. *This construction requires no lubrication.*

The main drive motor is equipped with pre-lubricated sealed bearings, and requires no attention. However the fan motor bearings should be lubricated as per instructions, Figure 14A and Page 15.

If the machine is operated more than one shift, it should be lubricated immediately before each starting time. A lubrication schedule tag tied to the machine will serve as a convenient reminder, and a central lubrication department will do a much better and more thorough job of oiling.

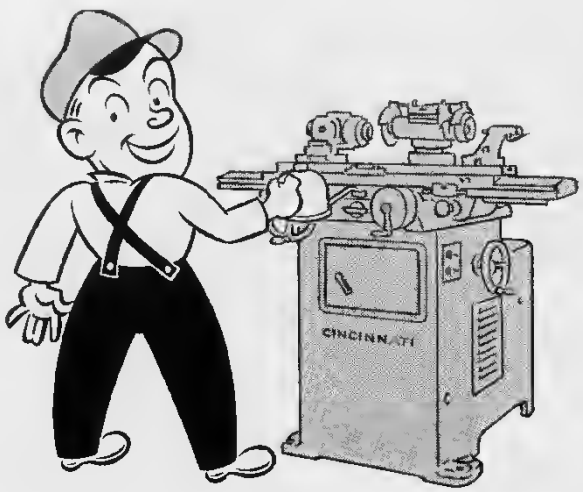


Figure 13A
Filling the Reservoir

LUBRICATION

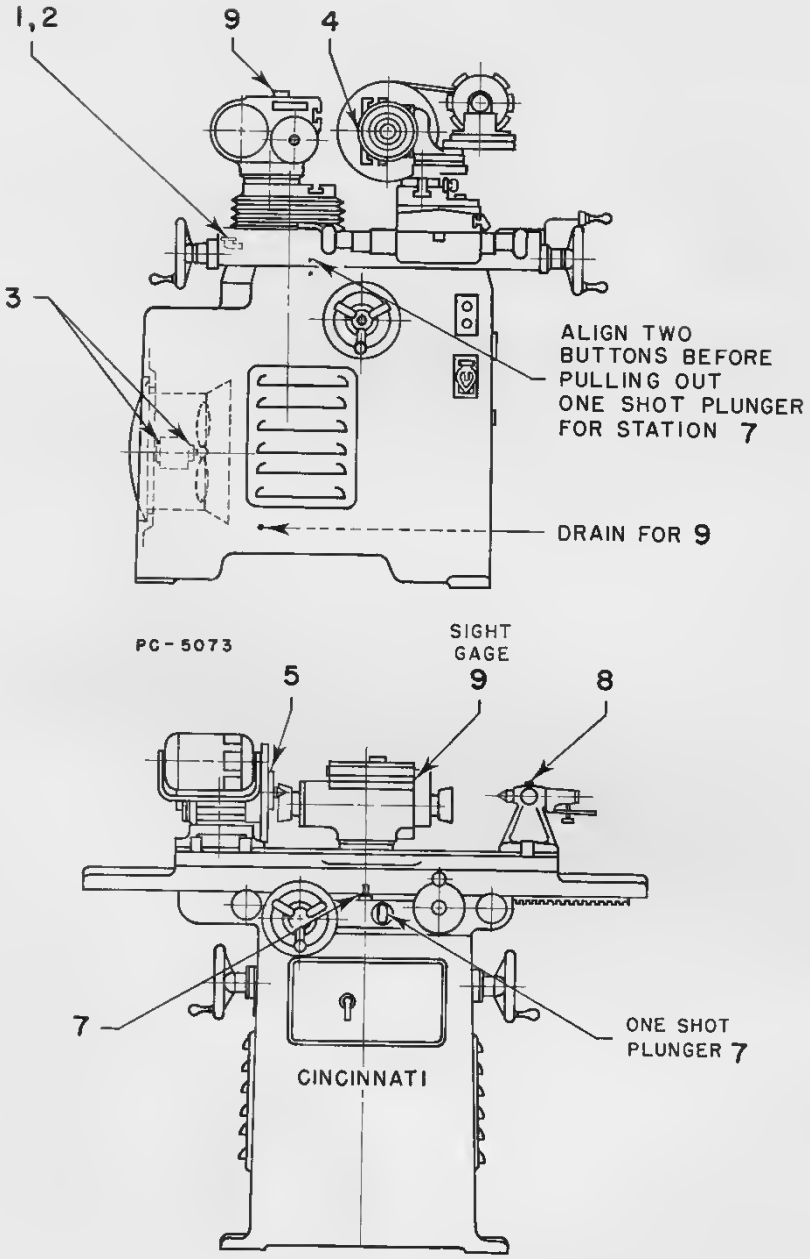


Figure 14A
Lubrication Diagram

LUBRICATION INSTRUCTIONS AND SPECIFICATIONS

When to Oil	Station Number	Instructions	Parts Lubricated	Specifications
Daily (8 hours)	1 and 2	Spring cap oil cups, keep filled, use bench oiler to fill.	Sleeve bearing in base.	P-47. A compounded medium-heavy oil for machine tool slideways. Viscosity 300 to 350 S.U.S. @ 100° F.
	4	Oil button. Apply a few drops, use a bench oiler. (Daily when used)	Front and rear spindle bearings in workhead. When using live center.	P-54. A rust and oxidation inhibited oil. Viscosity 300 to 320 S.U.S. @ 100° F.
	5	Oil hole. Apply a few drops, use a bench oiler. (Daily when used)	Work head pulley. When using dead center.	
	7	*Keep filled to top of screen filter. Use oil pot to fill. **Pull out plunger and allow it to return by itself.	Various bearings, cross feed nut and screw.	P-47. Same as above.
	8	Spring cap oil cup, keep filled. Use bench oiler to fill.	Retracting tailstock center.	P-54. Same as above.
	9	*Keep filled to high limit on gage. Use oil pot to fill. (Check Daily)	Filmatic spindle bearings in wheelhead.	P-62. A premium grade of spindle oil. Viscosity range 50-60 S.U.S. @ 100° F.
Every Three Months	3	Spring cap oil cups. (2 stations). Use bench oiler to fill.	Fan motor bearings. (Filmatic Spindle Machines)	P-54. Same as above.

*Quantities required: Station No. 7 approx. 1 qt., Station No. 9 approx. 1¾ qts.

**ALIGN TWO BUTTONS BEFORE PULLING OUT ONE SHOT PLUNGER FOR STATION No. 7.

Notes: In addition to the number of stations listed above, there is one additional station on machines having Power Table Traverse. See page 130 for instructions.

See Publication No. M-2258 for approved lubricants.

STARTING THE MACHINE FOR THE FIRST TIME

After the machine has been properly installed, wash off the slushing oil and dirt accumulated in transit with naphtha or a similar solvent of grease, making sure side ventilator panels are removed and the bottom of the wheelhead pile column (Figure 16A), which is exposed when wheelhead is in its lowest position, is thoroughly cleaned before vertical adjustment is made. Then fill all oiling stations with the grade of lubricant specified. This step is very important. Start the machine (See paragraph page 17 entitled "Starting the Machine"), and immediately notice the direction of rotation of the motor. This motor is of the instantly reversible type and the proper direction is difficult to determine. The correct direction of rotation can be determined by positioning the wheelhead directional switch in either the 'right' or 'left' position (Figure 17B) and noticing the direction of the grinding wheel spindle. If the 'right' position is used the spindle should rotate to the right when facing the side of the wheelhead.

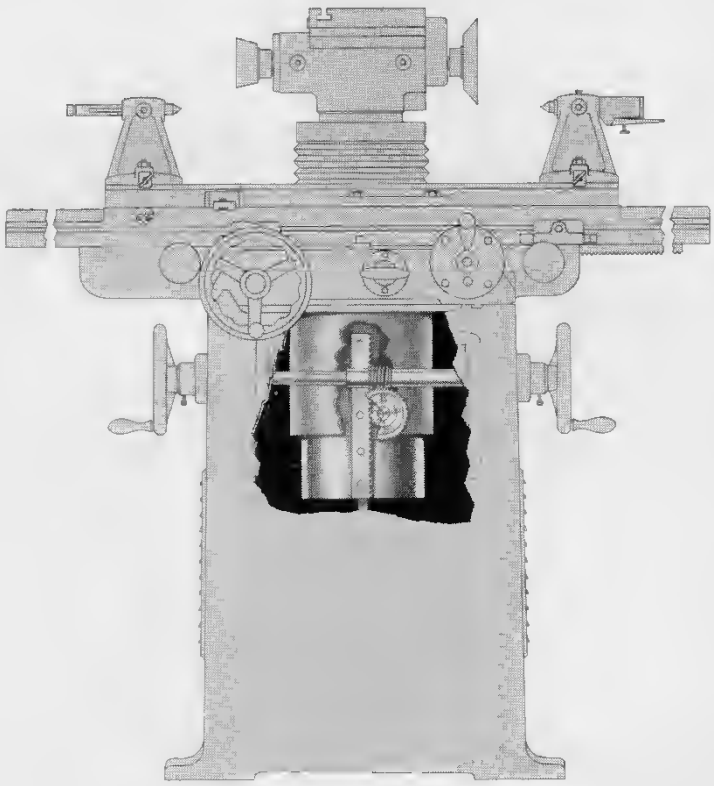


Figure 16A
Cut-away Front View Showing Bottom of Wheelhead Pile Column

OPERATING INSTRUCTIONS

Starting the Machine. When starting the machine for the day's work, fill all the oil holes and cups shown on the lubrication chart, (Figure 14A). Before operating the oil-shot pump (Station 7) be sure to line up the two buttons indicated in the lubricating diagram and on the instruction plate attached to the machine.

Electrical Controls. All CINCINNATI No. 2 Cutter and Tool Grinders are individually motor driven. All electrical controls are contained in the base of the machines. On the right and left sides of the base are the start and stop buttons (Figures 17A and 17B), for the grinding wheel spindle. The electrical switch for reversing the instantly reversible motor and direction of the grinding wheel is mounted on the same panel as the spindle start and stop buttons on the right side of the base (Figure 17B). On Universal Machines, an electrical outlet (Figure 17A) is provided for the purpose of plugging in the electrical cord for the cylindrical grinding attachment. The start and stop switch for this attachment is on the same panel with the start and stop buttons and the grinding wheel directional switch (Figure 17B). The main electrical panel and master switch are located in the front of the base (Figure 3A).

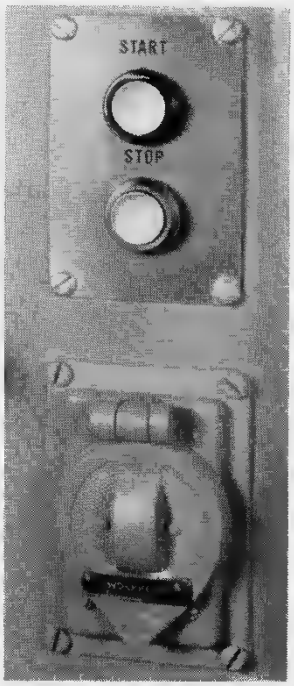


Figure 17A
Electrical Controls
Left Side of Base

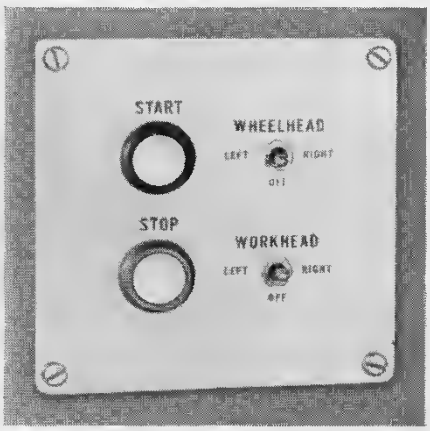


Figure 17B
Electrical Controls Right
Side of Base

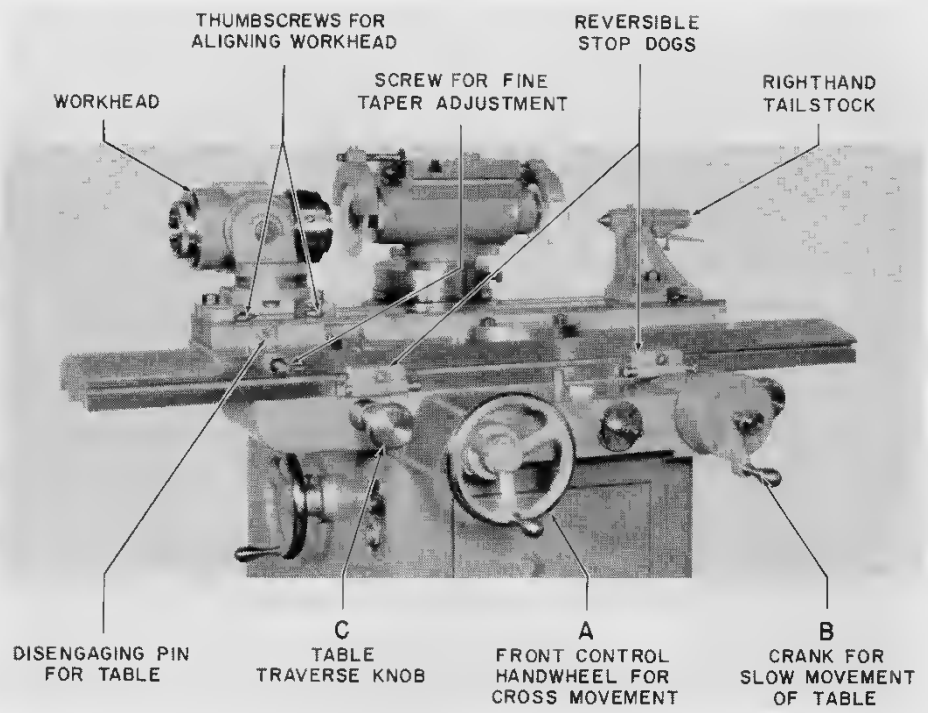


Figure 18A
Controls at the Front of the Machine

Table Traverse. Crank "B" (Figure 18A), through a 10½ to 1 differential gearing, moves the table from left to right when turned in a clockwise direction. One turn of the crank moves the table .374". Front and rear control knobs "C", (Figure 18A) and "E" (Figure 19A) are connected directly to a pinion which engages the table rack, and cannot be used until the differential crank "B" is disengaged. To disengage this crank, pull out the knob in the center of the crank housing.

Locking the Table Slide. The table slide may be locked in position by tightening the hand screw clamp illustrated in Figure 18B. Of course, the rear control traverse knob must be pushed in (pinion engaged with rack).

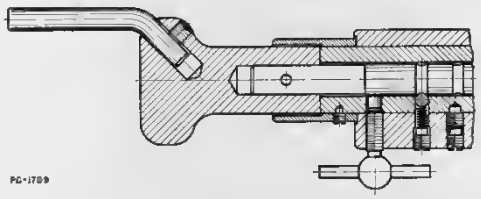


Figure 18B
Section Through Rear Control Table Traverse Knob, Showing Table Locking Screw

Cross Adjustment. Handwheel "A" (Figure 18A) moves the table and saddle away from the grinding wheel when turned in a clockwise direction. One turn of the handwheel moves the saddle $\frac{1}{8}$". The micrometer dial is graduated into 250 spaces, which is equivalent to .0005" movement of the saddle for each space.

Handwheel "D" Figure 19A is for the rear control movement of the saddle, and moves the saddle and table towards the grinding wheel when turned in a clockwise direction. The amount of movement per turn and the dial markings are the same as for handwheel "A".

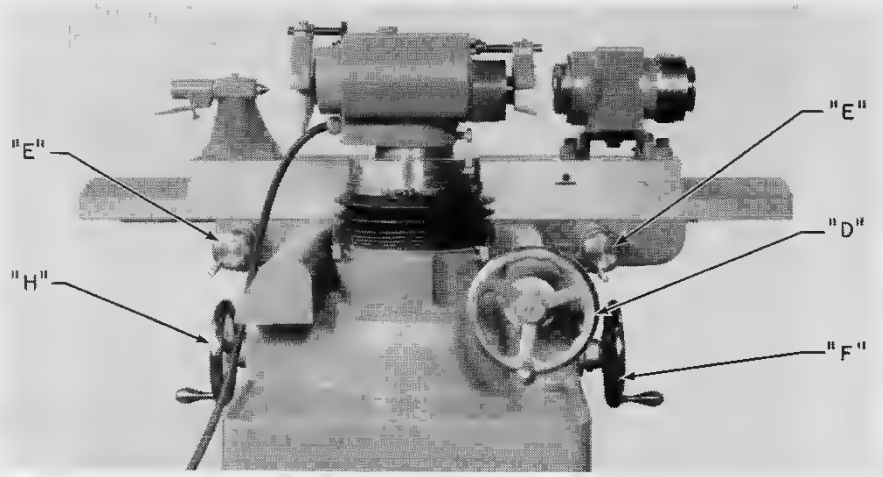


Figure 19A
Controls at the Rear of the Machine

Vertical Adjustment. Handwheel "F" Figure 19A moves the column and wheelhead up when turned in a clockwise direction. One turn of the handwheel moves the wheelhead $\frac{1}{10}$". The dial is graduated into 200 equal divisions, which is equivalent to .0005" movement for each division.

Handwheel "H" Figure 19A, which is a duplicate vertical control, is very convenient when working at the right hand side of the machine. The dial markings and the amount of movement for one turn are the same as for handwheel "F".

Setting Up the Tailstock and Workhead. When setting up the tailstock and workhead, tighten the thumbscrews in front of the unit before tightening the tee bolts for holding the unit to the table. This step is necessary as it assures positive alignment by locating the tongues and attachments against the same side of the table T-slots Tailstock centers can easily be removed and reversed. This enables the operator to have the retractable center or clearance setting dial center at either end of the table.

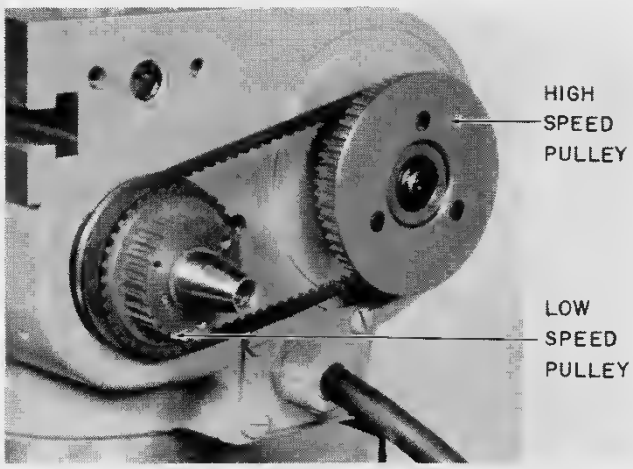


Figure 20A
Grinding Wheel Drive with Cover Removed

Spindle and Wheel Speeds. The wheelhead motor running at 3600 rpm on 60 cycle, drives the wheel spindle at 3890 and 6530 rpm. The drive is from a two step pulley on the motor shaft through a tooth-grip belt to a double step pulley on the wheel spindle (Figure 20A) This is a positive drive and no adjustment is ever required.

When using 6″ diameter grinding wheels and over, shift the belt to the inside pair of the double step pulleys, and when using smaller wheels, shift it to the outer pair of double step pulleys (Figure 20A).

Shifting the belt from one set of pulleys to the other is accomplished as follows:

1. Stop the spindle motor.
2. Loosen socket head screw and remove the sheet metal belt guard (Figure 20A). **Note:** If a grinding wheel is mounted on this end of the spindle, wheel guard and wheel assembly must be removed first.
3. Shift the tooth-grip belt to the desired set of pulleys, being sure the teeth in the belt mesh with those in each pulley.
4. Replace belt guard and tighten socket head screw.

The surface speed of the grinding wheel should be between 5000 and 6500 feet per minute to obtain the longest life and best cutting action of the grinding wheel (See Page 7 for Surface Speeds).

If the wheelhead motor is changed to one with a different speed, the pulley diameters must be increased or decreased to keep the proper wheel speed. Surface speeds can be determined from the following formulae:

$$\text{rpm spindle} = \frac{\text{rpm of motor} \times \text{diam. pulley on motor}}{\text{diam. pulley on wheelhead}}$$

$$\text{surface speed of wheel (ft./min.)} = \frac{\text{rpm spindle} \times 3.14 \times \text{diam. wheel}}{12}$$

Important. Use grinding wheel collets, collet parts and pulley drive for 8″ diameter wheels. See page 33

Figure 21A
Grinding Wheel Collet Assemblies are Quickly Interchanged by Removing Socket Head Screw

Grinding Wheel Collets. Always use compressible washers or blotting paper washers between the sides of the wheel, collet, washer or nut. This prevents unnecessary strains on the wheel center by distributing the clamping pressure evenly. Mount the wheel and collet on the spindle taper. Insert the socket head screw through the collet and thread into the spindle nose. Tighten collet utilizing "T" wrench and pin wrench, inserted in back of the collet, as shown in Figure 21A. See Page 33 for 8" diameter wheels.

Swiveling the Wheelhead. Loosen clamping screw "A" (Figure 22C), swivel grinding wheel to the desired setting, then retighten screw. For additional range provided by rotating the lower swivel, loosen lock screw "B" (Figure 22C), swivel the wheelhead to the desired setting, then tighten screw. Each swivel may be rotated through 360°.

360° Eccentric Wheelhead Swivel. The eccentric wheelhead swivel in conjunction with the adjustable wheelhead pile enables you to position the grinding wheel to suit any particular grinding application.

This additional movement of the wheelhead in the horizontal plane is obtained through two independent angular (360°) adjustments. The upper swivel (Figure 22C) carrying the grinding wheel is mounted eccentrically with respect to the lower swivel (Figure 22C) which is attached to the top of the wheelhead column. Both the upper and lower swivels may be rotated through 360°.

The eccentric arrangement (Figure 22C) adds 3½" of range to the 10" conventional movement of the cross adjustment (saddle). This not only permits positioning the grinding wheel directly over the table for surface grinding (Figure 22B), but in most instances it eliminates the need for spindle extensions when the wheelhead is moved to the extreme operating position (Figure 22A) when reconditioning miscellaneous small tools and cutters.

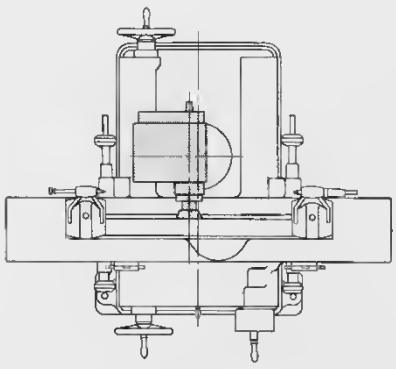


Figure 22A
Sufficient Range for Slab Mills and Other Arbor Mounted Cutters

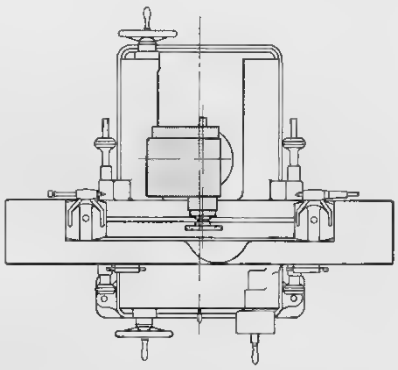


Figure 22B
Adequate Wheelhead Movement Over the Table for Surface Grinding

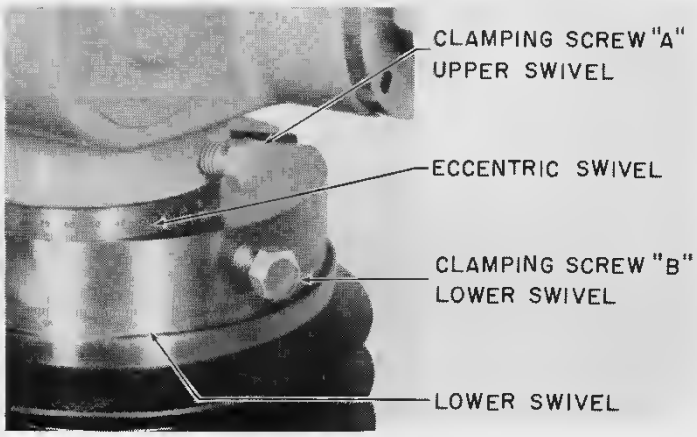


Figure 22C
360° Eccentric Wheelhead

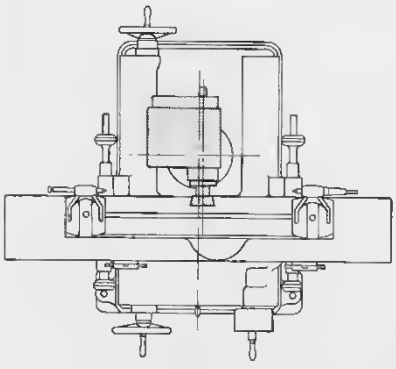


Figure 22D
Ample Capacity for Grinding Both Long and Large Diameter Cutters

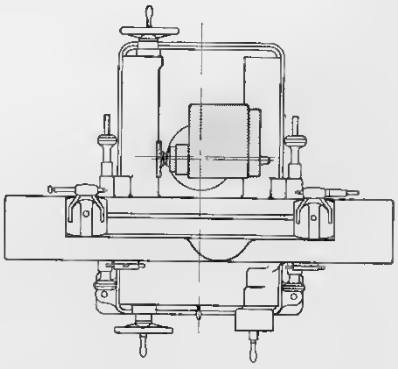


Figure 22E
Plenty of Range for Cylindrical Grinding Work up to 10½" in Diameter

Swivel Table "Tange-Bar Taper Setting Device" Adjustments. The workhead and/or the tailstocks are mounted on an auxiliary swiveling table, carried by the machine sliding table. This table provides the means by which the work may be swiveled clockwise or counter-clockwise to grind tapers. The swivel table may be clamped or unclamped in any position by means of the swivel table clamping screws (Figure 24A).

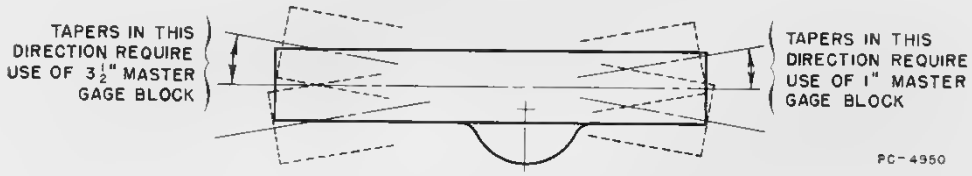


Figure 23A
Swivel Table and Master Gage Block Settings

To assist in accurately setting up for taper work, the left-hand end of the machine table is provided with a unique taper setting device that assures accurate grinding of tapers up to 5" per foot, without resort to a "cut and try" technique. Based upon the trigonometric function of the tangent of the angle, the "Swivel Table Tange-Bar Taper Setting Device" (Figure 24A) enables you to adjust the swivel table to the correct taper per foot simply by inserting precision gage blocks between the swivel table taper setting master gage block and a stud on the sliding table (Figure 24A).

For example, if you desire to set the table to grind a tool having .050" taper per foot on the diameter, proceed as follows:

1. Loosen swivel table clamping screws and position swivel table until there is sufficient room to insert master gage blocks supplied with the machine and precision gage blocks equal to .025", one half of the 050" taper per foot desired. (Figure 24A).

   Selection of the 1" or 3½" master gage block depends upon the direction in which the machine table is swiveled in order to provide the desired taper (Figure 23A).

2. Insert master gage block so that it contacts locating pin on swivel table. Then insert precision gage blocks between master gage block and locating pin on sliding table

3. Position swivel table until locating pin on swivel table contacts the top of the master gage block.

4. Tighten swivel table clamping bolts

Computation of the gage block setting, when the included angle of the taper is known, is obtained by multiplying the tangent of one half the known value of included angle by 12. Replacing either this value or the given value of taper per foot from the centerline, as the case may be, with the corresponding precision gage blocks enables you to accurately position the swivel table to grind the taper Greater swivel settings of the table, as sometimes required when grinding large cutters, may readily be obtained. Rotate the swivel adjustment disengaging pin ½ turn (Figure 25A), remove master gage blocks (Figure 24A), and with the clamping bolts loose, swivel the table to the desired angle using the graduated scale on the swivel table (Figure 24A).

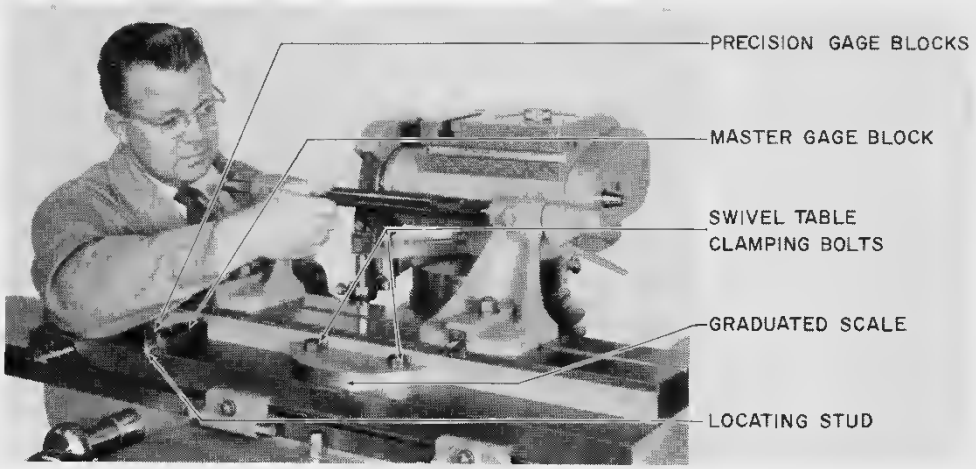


Figure 24A
Tange Bar Taper Setting Device

In the normal position of the swivel table, the center of the T-Slot is offset 1¾" from the pivot stud. towards the wheelhead. Since the table may be swiveled 180°, the normal cross range is increased 3½" as shown in Figure 26A. A secondary advantage in swiveling the offset table 180° is that the center of gravity of any attachment and its cutter is shifted 3½" towards the front table way: an important point to remember when grinding heavy parts which overhang the table on the grinding wheel side.

Swivel Table "Taper Per Foot Device" Adjustments. The swivel table may be adjusted forward or backward (considering the graduated end) for tapers up to 2 inches per foot, indicated by the scale in the sliding table. Loosen the two clamping bolts before turning the swivel adjusting screw (Figure 25A).

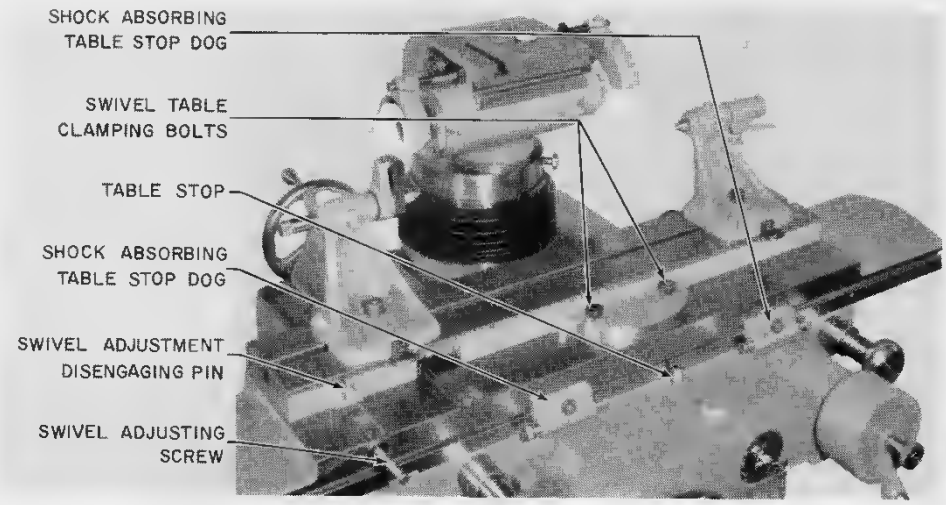


Figure 25A
Close-up of Swivel Table Adjustment and Shock Absorbing Table Dogs

Fine Adjustment for Matching Angles. With the "Taper Per Foot Device" and the aid of an indicator gage, very fine and very accurate adjustments can be made. This is especially useful on jobs where previously ground angles must be matched. Clamp an indicator gage in the T-Slot on the front of the longitudinal table, with the gage finger contacting the swivel table (Figure 25B). Of course, the gage will not be graduated in taper per foot, but with little practice, it will greatly reduce the number of cut-and-try settings required to obtain an exact bearing the full length of the previously ground angle.

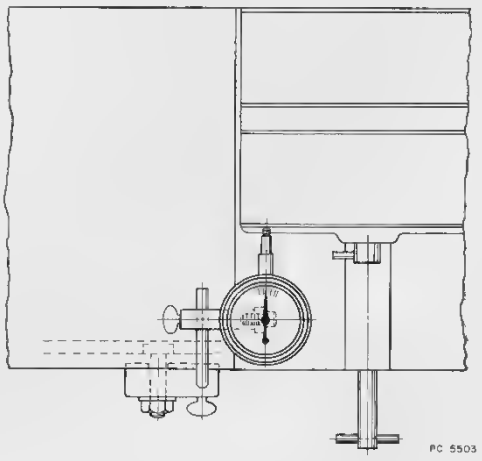


Figure 25B
An Indicator Gage Will Help in Making Fine Adjustment

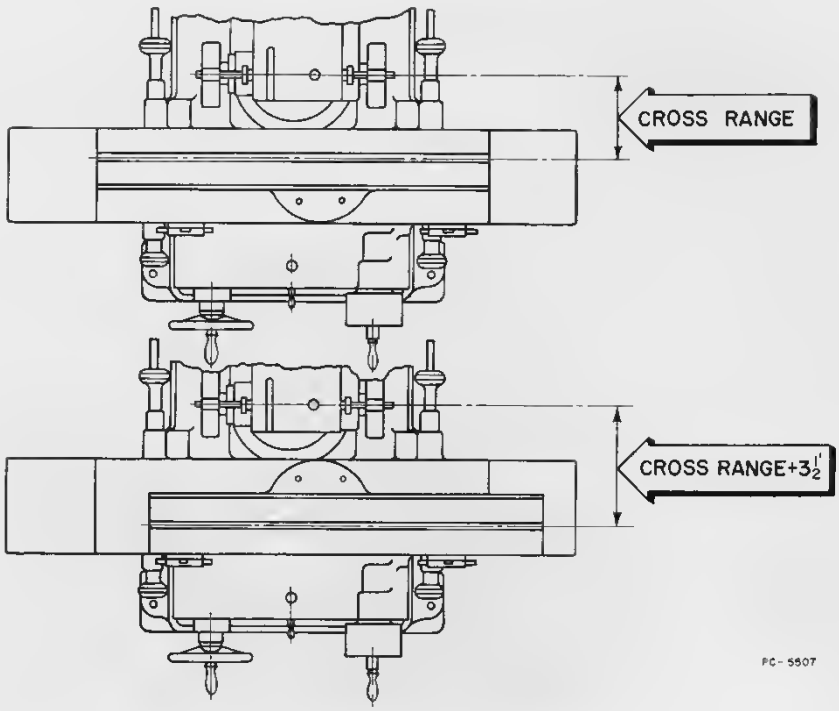


Figure 26A
Swivel Table Rotated 180°

Table Dogs. The table dogs can be used either for positive stop or spring cushioning the table stroke. When set as shown in Figure 25A, these dogs will not only govern the length of table reverse but absorb the shock at the end of each stroke and smoothly reverse the direction of the table. If a positive stop is necessary, remove nut holding dog to front table "T" slot and reverse dogs from one side to the other. Also in this position, a fine adjustment can be made by merely screwing out knurled screws on the dogs (Figure 27A). The spring cushioning position is generally the setting for the majority of cutter sharpening operations.

Centering Gage. The centering gage, (Figure 27A), is for the purpose of quickly aligning a cutter tooth with the tailstock center and with the center of the grinding wheel spindle when setting up the machine. This result is accomplished with the gage placed on top of the wheelhead or on the table (Figure 27A).

Notice that opposite sides of the small diamond shaped gage-plate are finished machined. By merely swiveling the plate to bring the machined side in contact with the cutter tooth, both right hand and left hand cutters may be centered (see Figures 27B and 27C).

Sometimes a preliminary step in the set-up requires that the wheel column be "set to zero". That is, the center of the grinding wheel must be the same height from the table as the tailstock centers. A zero-line is stamped on the face of the wheelhead for this purpose. The setting may be accomplished by placing the centering gage on the table, and adjusting the column to match the zero line with the gage (Figure 27A).

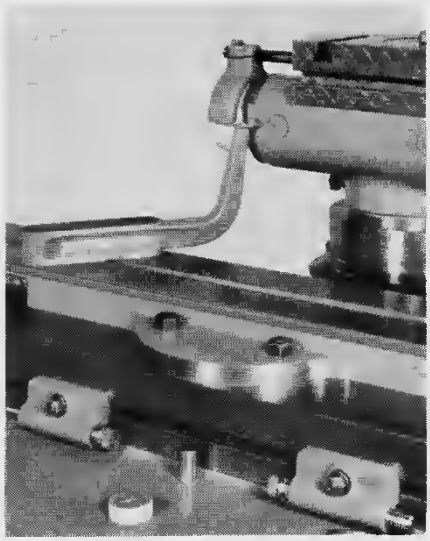


Figure 27A
Centering Gage on Table Indicating Zero-Mark on Wheelhead

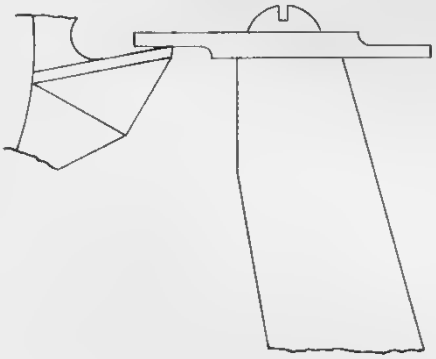


Figure 27B
Centering Gage on Table

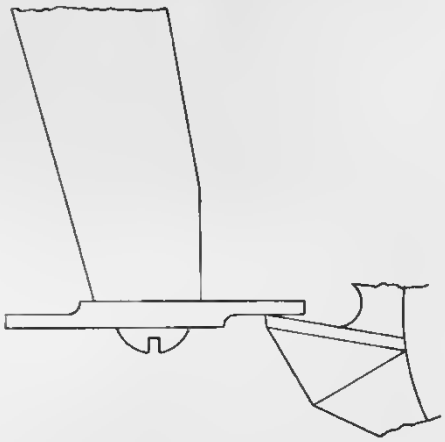


Figure 27C
Centering Gage on Wheelhead

Grinding Wheels. When grinding a high speed steel cutter or reamer, use a hard wheel. A hard wheel will not readily break down when grinding, therefore, maintaining accuracy and size on the tool being ground. However, it must be remembered when using a hard wheel that the contact area of the wheel must be kept to a minimum for the particular grinding job being done. This practice will prevent the wheel for loading up and burning the cutter. Some jobs, particularly surface grinding, requires

wheels not listed in the table. We can supply them, when required, at extra cost. See pages 112 and 113 for list of wheels and their uses.

Direction of Rotation of Wheel. The normal direction of rotation of the grinding wheel is towards the cutting edge of the cutter, as shown in Figure 28A. The chief advantage when using this method, is that there are no burrs left on the cutting edges of the teeth to be removed by a painstaking oil-stone operation. However, if you believe that the grinding wheel should rotate in the opposite direction (Figure 28B) the grinding wheel can easily be reversed by means of the switch located on the right side of machine base as shown in Figure 17B. The chief advantage is that the grinding action forces the cutter, being sharpened, down on the tooth rest, so that it can not rotate out of the operator's hand, causing an injury to him.

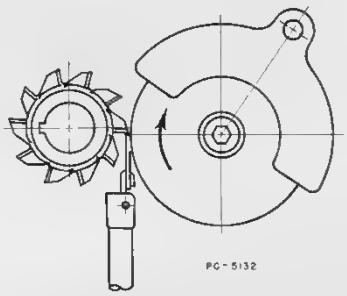


Figure 28A
Grinding Wheel Rotating Towards the Cutting Edge

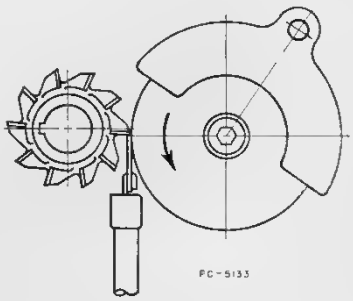


Figure 28B
Grinding Wheel Rotating Away From the Cutting Edge

Truing the Wheel. The grinding wheel must be trued occasionally during grinding operations. Careful truing will keep the wheel concentric, free of foreign particles and free cutting. For this operation, the wheel truing attachment shown in Figure 28C is supplied. Use the differential hand control to give the table a uniform motion, because the diamond will produce a much better surface on the wheel if it is traversed uniformly.

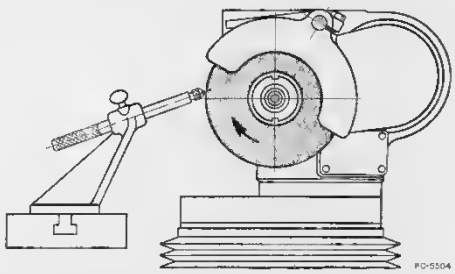


Figure 28C
Wheel Truing Attachment

Pause momentarily after each pass of the diamond across the wheel, allowing the truing tool to dissipate some of the heat which is generated. This simple precaution will greatly increase the life of the diamond. Remember that it is more economical to reset a worn diamond than to continue using it, because of the possibility of damaging it beyond further use.

Do not take a cut of more than .001" across the face of the wheel

Clearance Setting Dials and Dog. The clearance setting device for the left hand tailstock, illustrated in Figure 29A, must be set in conjunction with dog A. Clamp the dog to the arbor, on which the cutter is mounted with the pin inserted in the hole in the clearance setting plate. Loosen thumb screw B, rotate the cutter to the desired clearance as indicated by the graduations at C, then tighten the thumb screw and remove the setting dog. This device is employed when sharpening a plain milling cutter, pages 37-39

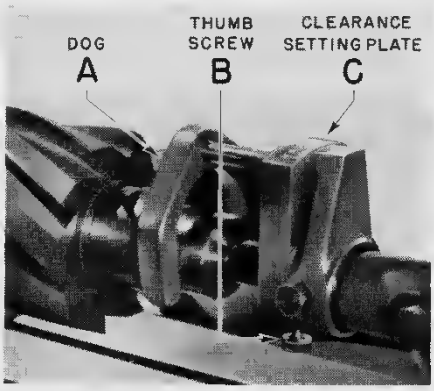


Figure 29A
Clearance Setting Device on Left-Hand Tailstock

Three diameters on the workhead are graduated for convenience in setting up the job as well as providing an accurate determination of clearance angles (Figure 29B).

a. Clearance setting dial at one end of the spindle housing.
b. Clearance and set-up graduations for the vertical swivel bearing
c Clearance and set-up graduations for the horizontal swivel bearing.

A knurled thumbscrew in front of the head (not visible) tightens the spindle in position while the vertical and horizontal swivels are each tightened with a single wrench.

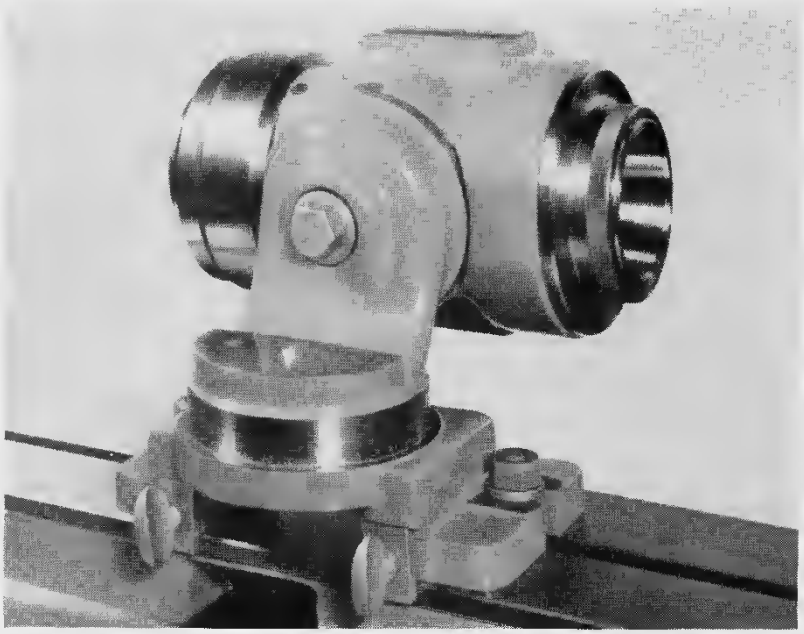


Figure 29B
Clearance Setting and Set-up Graduations on Workhead

Tooth Rest. Typical tooth rest blades are shown here, with brief comments on the use for each type. When the requirements for blades are thoroughly understood, other shapes can readily be fabricated to suit special types of cutters.

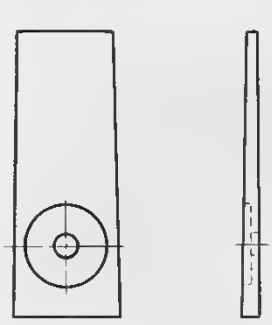


Figure 30A

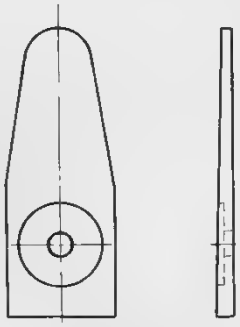


Figure 30B

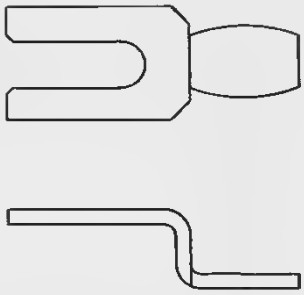


Figure 30C

Figure 30A—Straight blade. Used with adjustable holder for grinding straight fluted reamers, side mills, end mills or any type of straight fluted cutter.

Figure 30B—Tooth rest blade with a radius end. Used for sharpening shell end mills, small end mills, taps and reamers.

Figure 30C—Offset tooth rest blade. Used for sharpening large diameter, coarse pitch spiral milling cutters, large face mills that have angular blade inserts and close tooth stagger tooth cutters.

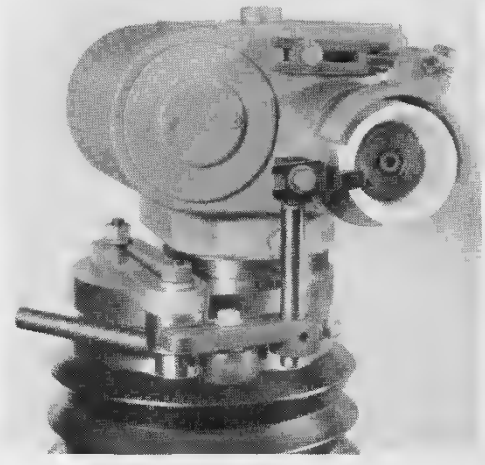


Figure 30D
Plain Tooth Rest

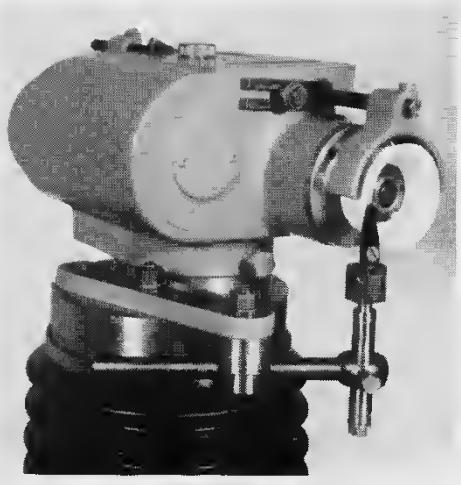


Figure 30E
Universal Tooth Rest

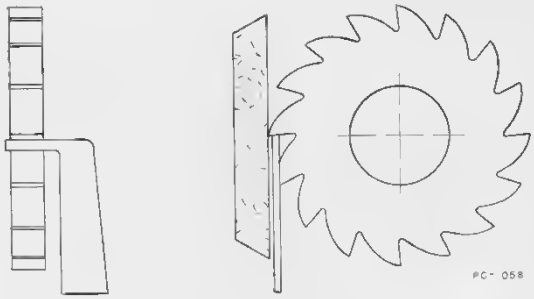


Figure 31A

Figure 31A—L-shape tooth rest blade for sharpening metal slitting saws and straight tooth plain milling cutters with closely spaced teeth. These blades are not carried in stock, but they can readily be made in the average shop Use oil hardening tool steel

Good Housekeeping. Because of the four operating positions—front and rear, right and left—provided by the front and rear dual controls, it is advisable to keep the floor clean and free of loose parts and attachments. In other words, practice good housekeeping in the vicinity of your machine. A cabinet for the attachments, wheels, wrenches, etc. will prove a big help It can readily be made by your shop carpenter, or we can supply a "Cabinet for Tools", either wood or steel, at extra cost

Figure 31B
Cabinet for Tools

SAFETY PRECAUTIONS

Wear Goggles. Eliminate the possibility of eye injury by wearing goggles or some approved form of eye shield.

Wheel Guards. Do not run the machine without wheel guards.

Flanges, Washers, and Nuts. All abrasive wheels must be mounted between flanges

Washers or flange facings of compressible material should be fitted between the wheel and its flanges. If blotting paper is used, it should not be thicker than .025". If rubber or leather is used, it should not be thicker than 1/8". If flanges with babbitt or lead facings are used, the thickness of the facing should not exceed 1/8". The diameter of the washer shall be the same size or slightly larger than the flange diameter.

All surfaces of wheels, washers, and flanges in contact with each other should be free from foreign material.

Inspection and Storage of Wheels. Competent men should be assigned to the mounting, care, and inspection of grinding wheels.

Immediately upon receipt, all wheels should be closely inspected to be sure that they have not been injured in transit. Inspect for cracks by tapping gently (while suspended) with a light implement, such as the handle of a screw driver. Wheels must be dry and free from sawdust when applying this test. If they sound cracked they must not be used. Note that organic bonded wheels do not emit the same clear metallic ring as do vitrified and silicate wheels.

Extreme care should be exercised in the storage of wheels. They should be stored in a dry place and should be supported by pegs in racks.

Operating Rules and General Data. Run all new wheels at full operating speed for at least one minute before applying the work, during which time the operator should stand at one side.

Work should not be forced against a cold wheel, but applied gradually, giving the wheel an opportunity to warm and thereby minimize the chance of breakage. This applies to starting work in the morning in cold rooms, and to new wheels which have been stored in a cold place.

Grinding on the flat sides of straight wheels is often hazardous and should not be allowed on such operations when the sides of the wheel are appreciably worn, or when any considerable or sudden pressure is brought to bear against the sides. When it is necessary to grind on the sides of a flat wheel, they should be slightly hollowed to have less contact area.

When tightening the spindle end screw, care should be taken to tighten it just enough to hold the wheel firmly: otherwise the clamping strain is liable to damage the spindle or associated parts.

Do not use wheels of a larger diameter or a greater thickness than specified for this machine. (See list of wheels, pages 112-113).

Loose clothing, arm and finger jewelry should not be worn when operating this machine.

The space about the machine should be kept light, dry and as free as possible from obstructions

All machines, except those permanently set up with a mist grinding attachment, should be attached to a dust exhausting system. (See page 108).

Conforming to the safety codes, when using the 8″ diameter grinding wheels, larger wheel collets should be used. Also in order that the correct surface speed be maintained for these larger grinding wheels an extra set of motor pulleys, designed for these wheels, should be purchased, see pages 118 and 119 items 11, 12 and 13.

CLEARANCE ANGLES
For Milling Cutters

Milling cutters ground on CINCINNATI No. 2 Cutter and Tool Grinders fall into two distinct classes, each class being sharpened by a method peculiar to itself.

Into the first class fall the cutters which are sharpened on the periphery or outside diameter by grinding a cutting and clearance angle behind the cutting edge. The great majority of milling cutters are of this type, of which an ordinary plain milling cutter is an example. This type of cutter can be refluted and used over again when the teeth are ground down too small.

The second class includes cutters which are form relieved and which must be sharpened by grinding the front faces of their teeth. These cutters have a definite profile for producing a given outline, the cutter profile being preserved when sharpening by grinding the front faces of the teeth only, remembering to maintain the original rake angle. The clearance is produced during the manufacture of the cutter. Gear cutters, form milling cutters, etc.

When setting up for grinding *radial* tooth form relieved cutters, bring the center of the cutter in line with the face of the grinding wheel. For *undercut* form relieved cutters, proceed as before. swivel the table or cutter through an angle equal to its rake angle and then align the face of one cutter tooth with the face of the wheel. If the rake is marked on the cutter in thousandths of an inch, (Dimension "D" in Figure 59A), offset the center of the cutter from the face of the wheel by this amount. Set the face of a cutter tooth against the face of the grinding wheel, and set the tooth rest against the heel of the tooth. To adjust the work to the wheel, revolve the cutter towards the wheel a slight amount by adjusting the micrometer tooth rest. The faces of the teeth will then be ground to maintain the correct cutter profile. (Also see discussion under "Grinding Form Relieved Cutters", pages 56 to 59).

The clearance angle is the most important consideration when grinding a milling cutter which is included in the first class. Clearance angles should be held to a minimum for the particular job it is to be used on. .

Chatter in the finish milled surface may be caused by an incorrectly ground cutter, or by a poorly designed cutter. It may also be due to the shape of the part being milled, method of clamping the work; type of fixture; locating points and pads; and finally, the condition of the milling machine on which the job is milled.

The clearance angle should be carefully selected for all types of cutters. The value of the clearance angle plays an important role in obtaining good cutter performance, high cutting efficiency, and long cutter life between grinds It is desirable in all cases to use a clearance angle as small as possi-

ble, so as to leave more metal for heat dissipation, and insure maximum strength of the cutting edge. Any clearance angle greater than required by the cut will weaken the cutting edge, and may cause failure under heavy duty operation. It will also increase the likelihood of chatter, resulting in a poor finish on the machined surface and reducing the life of the cutter.

Repeated sharpenings increase the width of land, until interference develops at point "E" (Figure 35B). To eliminate interference, reduce width of land by grinding secondary clearance.

A third clearance angle is sometimes necessary when a cutter has been repeatedly sharpened to the extent that the tooth depth becomes very small and the tooth thickness becomes very great. The third angle should be great enough to remove any metal which interferes with chips entering the chip space

Generally accepted values of clearance angles are given in the table at the right. However, many factors and conditions such as the type of machine, type of cutter, set-up and etc., may vary these angles so that they may have to be changed to meet the demands of the particular job being done

Approximate Clearance Angles for High Speed Steel Milling Cutters

Work Material	Primary Clearance Angle	Secondary Clearance Angle
Alloy Steel	3—5°	3—5°
Mild Steel	3—5°	3—5°
Cast Iron	4—7°	3—5°
Bronze (Hard)	4—7°	3—5°
Brass	10—12°	3—5°
Aluminum	10—12°	3—5°

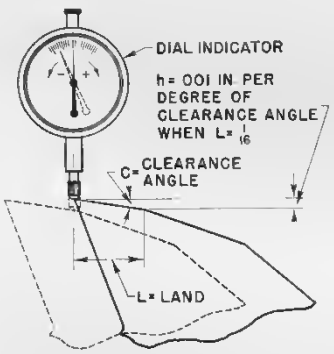


Figure 35A
Measuring the Clearance Angle with a Dial Indicator

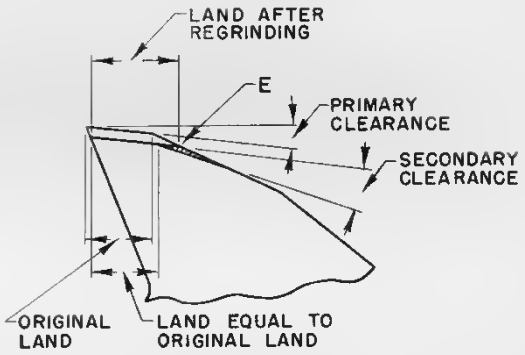


Figure 35B
Clearance Angles and Land.

After you have once found the best clearance angles for a particular job, then write down the part number of the work-piece, the number of the cutter, and the clearance angles, so that you can duplicate the results. Suggested record on page 96.

Drawings of inserted cutter teeth are shown in Figure 36A. The enlarged section of the blade, Figure 36B, shows three types of corners for shell end mills and face mills.

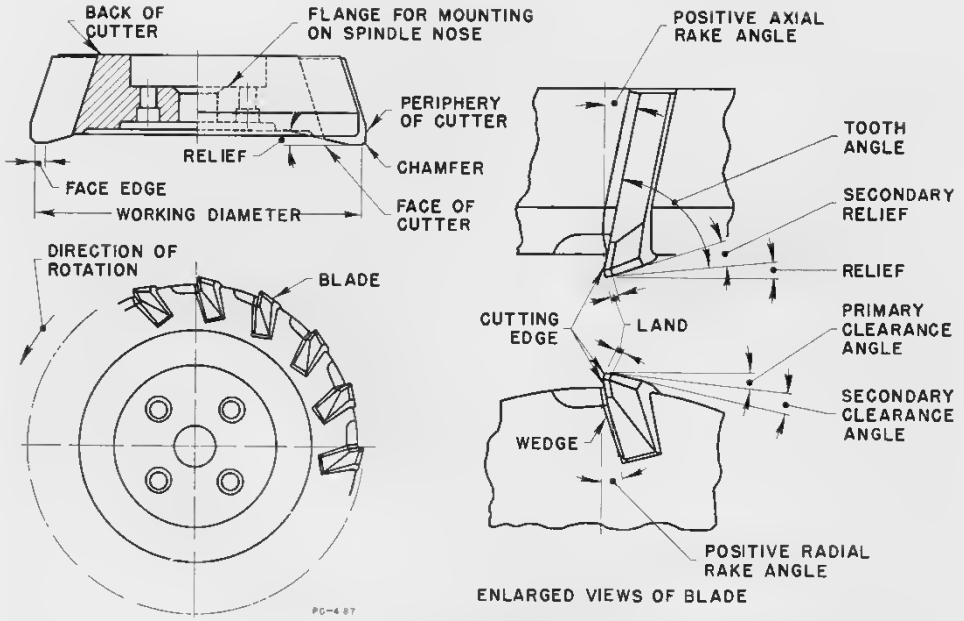
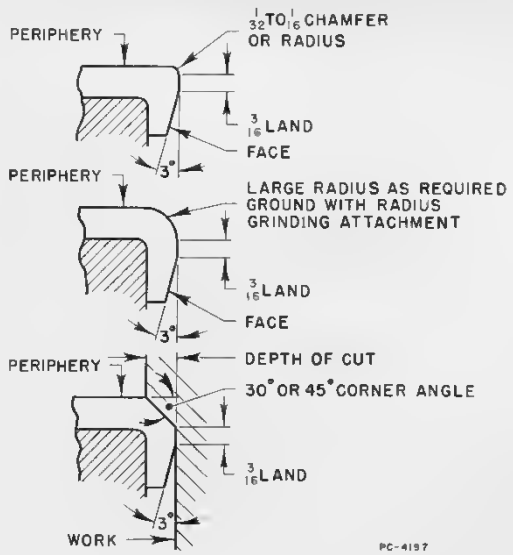


Figure 36A

Nomenclature of Face Milling Cutter. Relief angle should be 3° to 5° and width of land from 1/64" for small face mills to 1/16" for large face mills.



SHARP CORNER

For milling up to an approximate sharp corner.

RADIUS

For milling a radius. The corners of the teeth are ground to the same radius as desired on the work with the aid of the No. 1 or No 2 Radius Grinding Attachment.

CHAMFER

For milling flat surfaces without projecting shoulders. Grind to 30° corner angle for longest cutter life and for deep cuts. Grind to 45° corner angle for best finish on the work

Figure 36B
Three Types of Corners
For Shell End Mills and Face Mills

GRINDING CUTTERS

A variety of types of cutters can be ground on the CINCINNATI No. 2 Cutter and Tool Grinder without the use of attachments; that is, by using only the standard workhead and tailstocks. In this group of cutters may be listed:

Plain Milling Cutters	Angular Cutters
End Mills	Face Mills
Shell End Mills	Saws
Slotting Cutters	Form Milling Cutters
Keyway Cutters	Taps
Stagger Tooth Cutters	Hobs
Side Milling Cutters	Reamers

Grinding a Plain Milling Cutter With Helical Teeth. We will go through the various steps necessary in setting up for and grinding a plain milling cutter with helical teeth, since the method of sharpening many cutters is essentially the same except the slight differences as noted in later

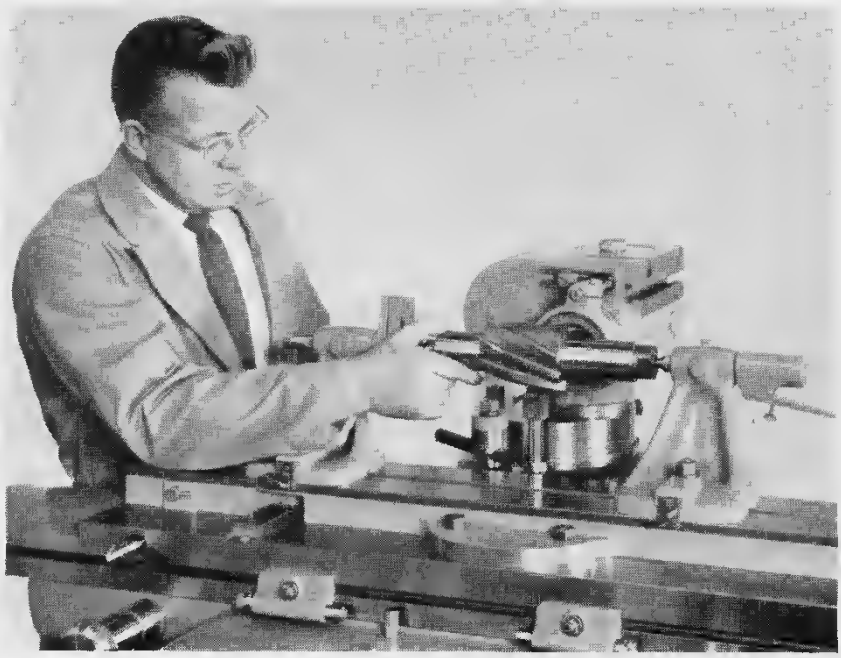


Figure 37A
Grinding A Plain Milling
Cutter with Helical Teeth

paragraphs. These steps are given in detail and therefore seem rather long, but the total time required for this cutter grinder set-up is surprisingly short because of the convenience in making the various adjustments.

1. Adjust the saddle away from the wheelhead to allow plenty of space for the set-up. Clean the table and bottom of the right and left hand tailstocks. Clamp them on the table, properly spaced for the arbor (item 33, page 122), or mandrel used for the set-up.
2. Mount clearance setting dog to left-hand tail stock.
3. Clean the arbor, collars, and cutter hole. Mount them on the arbor, lightly clamp with the nut, and place the assembly between centers.
4. Fasten the wheel mount—collet and flared cup grinding wheel Print No. 11Y—120 to either end of the wheelhead spindle.
5. Swivel the eccentric wheelhead one degree from a 90 degree setting
6. Check the wheel speed. The belt should be on the high speed pulley.
7. Mount the tooth rest assembly on the wheelhead, using the solid post type with offset blade (Figure 38A).

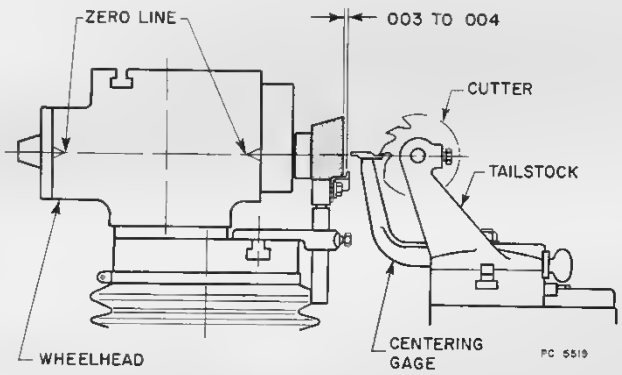


Figure 38A
Cutter and Wheelhead Set at Gage Height

8. With the centering gage on table, temporarily position the offset blade approximately on the center line of the grinding wheel and on center of the cutting edge on the face of the grinding wheel.
9. Traverse saddle toward wheelhead until one cutter tooth rest on the blade.
10. Find the point of contact between cutter tooth and toothrest blade by red-leading the toothrest blade and rubbing the cutter tooth across it Traverse table away from setup and lock in this position.
11. Position this contact point in the center of the cutting edge on the face of the grinding wheel Fasten in position

12 With centering gage on the table, position the point of contact on center with the gage by raising or lowering the wheelhead.

13 Clamp the clearance setting dog on the arbor.

14. With a cutter tooth resting on the tooth rest, lower the wheelhead until the desired clearance is indicated on the clearance setting dial. Closely spaced teeth may limit the amount of clearance angle obtainable.

15. Remove the clearance setting dog and unlock the table.

16. Run through the set-up without grinding. With one hand, traverse the table (using the rear control) and with the other hand hold the arbor just firmly enough to keep the cutter tooth against the blade (Figure 37A)

17 Swing the master electrical switch, front of the machine, to "ON" position. Stand away from the wheel, and push the starting button, see page 17. Allow the wheel to run about one minute

18. Adjust the saddle until one cutter tooth lightly contacts the wheel. Grind one tooth. Rotate the cutter 180° and grind the opposite tooth. Check with micrometers for taper.

19. Remove taper, if any, by means of adjusting the set screw on rear side of table, to reset tange-bar taper setting device and align swivel table parallel to grinding wheel face. Check alignment with an indicator. mounted on wheelhead. See page 109 for complete adjusting instructions.

20. Grind the remaining teeth Remember to adjust for wheel wear.

21. If the land is too wide, a secondary clearance can now be ground. It should be about 1/16" for average to large diameter cutters and narrower for small cutters.

Notice that the flare cup wheel is shown in the illustrations for the above grinding set-up. This type of wheel is shown because it produces a flat land clearance instead of hollow land produced by the disc wheel. However if a hollow land is preferred a disc wheel may be used. These instructions are the same for the disc wheel.

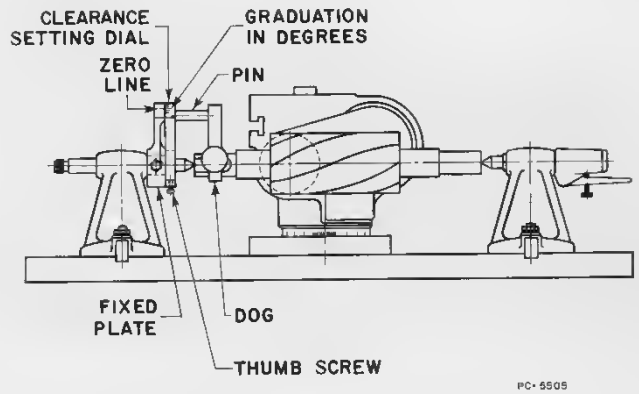


Figure 39A
Adjusting the Cutter to the Clearance Angle with the Aid of the Clearance Setting Dog

Grinding an End Mill. Refer to pages 38-39 for basic instructions. Much the same practice is carried out when grinding an end mill as when grinding a plain milling cutter. The main difference is that the ends or face of the teeth and the corners must also be sharpened, requiring two additional set-ups.

Note: To insure a sufficient amount of space for tilting the workhead to obtain cutting clearance on the face of larger diameter shell mills, a raising block should first be placed on the table with the workhead bolted on top of it, (Figure 40C). This will save time in changing the setup when this operation is to be done. See item 30, page 122 for raising block.

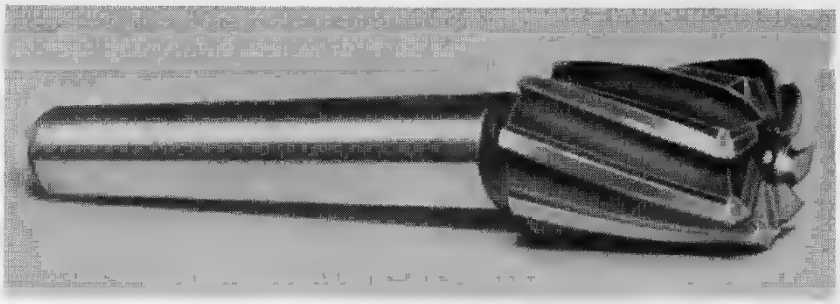


Figure 40A—End Mill

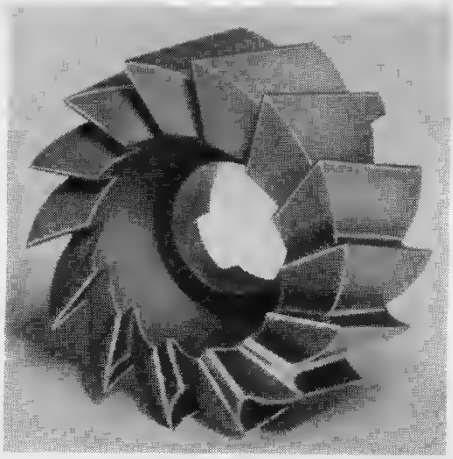


Figure 40B—Shell End Mill

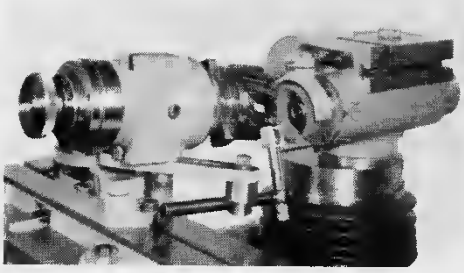


Figure 40C
Grinding the Face of a Shell End Mill Cutter

After grinding the periphery of the teeth, proceed as follows to set up for grinding the face of the cutter.

1. Mount raising block on table and fasten workhead to it, position on table. Insert the cutter in the workhead.
2. Swivel the cutter downward to the desired clearance angle, and clamp in position.
3. With the aid of the centering gage, level one tooth in a horizontal plane with the table.
4. Lock the workhead spindle in place.
5. Clamp the tooth rest in place on the workhead (see Figure 40C), resting the blade against the under side of the tooth to be ground.

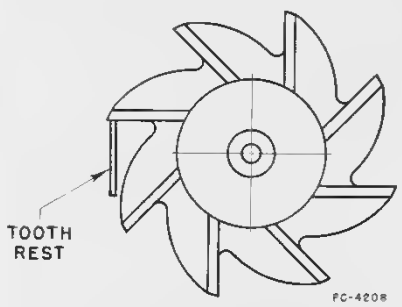


Figure 41A
Tooth Rest Blade in Position for Right Hand Mill

6. Fasten wheel guard and wheel Print No. 11Y–120 flaring cup—3½" diam. x 1½" x 1¼" hole to either end of the spindle, and swivel the eccentric wheelhead one degree from a 90° setting.
7. Lower or raise the wheelhead so that the tooth next to the one being ground will clear the wheel.
8. Loosen the workhead spindle thumb screw, and proceed to grind. **Note**—Don't forget to adjust for wheel wear.
9. On shell end mills, it is advantageous to back off the faces of the teeth towards the center of the cutter, similar to the tooth of a face mill, page 36. An angle of about 3° to 5° is sufficient, allowing a land of 3/16" long.
10. Re-set for the secondary clearance and grind, using the same procedure as outlined above

It is important that as much care be used when grinding the corners of the teeth as when grinding the face or periphery; otherwise the cutting edges will dull rapidly, and a poor finish will be obtained.

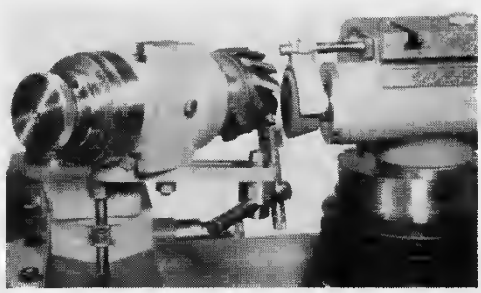


Figure 41B
Grinding the Corners of the Teeth of a Shell End Mill

To grind the corners, proceed as follows

1. Swivel the workhead to a convenient position so the centering gage can be used from the table, to center a point approximately in the middle of the cutter chamfer in the same horizontal plane as the centerline of the workhead
2. Lock the workhead spindle thumbscrew.
3. Swivel the workhead in the horizontal plane to the corner angle desired as shown by the graduations on the base. 45° is the most common (Figure 36B)
4. Set the radial tool dial to zero and lock in position.

5. Tilt and roll the workhead to the desired amount of clearance (see pages 114 and 115). Remember to loosen the workhead spindle thumbscrew before attempting to roll.

6. Retighten workhead spindle thumb screw.

7. Mount the toothrest assembly on the workhead, positioning the toothrest blade under the cutter tooth to be ground

8. Loosen workhead spindle thumb screw and proceed to grind.

Note: Large chamfers should be ground by rolling the tooth over an offset blade mounted on the wheelhead

The above instructions are for a right hand milling cutter

If the cutter is left hand, the setup for grinding the chamfer or face of the cutter (page 40) is the same as outlined, except for the changes in the following steps.

Tilt the workhead up for the desired face clearance, and clamp in place.

Tilt and roll the workhead up to the required chamfer clearance, and clamp in place. See page 114

Remount tooth rest assembly from bottom of the universal workhead to the top.

Raise the wheelhead so that the bottom of the wheel will clear the tooth next to the one being ground.

Grinding Small Diameter Face Mills. Grinding a small diameter face mill of 8" diameter or less, using the workhead as the cutter support, is essentially the same as grinding a shell end mill. The flaring cup wheel—3½" diam x 1½" x 1¼" hole Print No 11Y–120 is used for all operations A special arbor which will accommodate face mills of standard design is supplied on demand at extra cost.

Grinding a Keyway or Slotting Cutter. Refer to pages 38-39 for basic instructions. When grinding this type of cutter, practically the same set-up is used as for grinding plain milling cutters with helical teeth, except that if the teeth are straight, the tooth rest is clamped to the workhead or table

Grinding a Side Milling Cutter. Refer to pages 38-39 for basic instructions Figure 43A shows the outline of a side milling cutter; that is, one which has teeth on the sides as well as on the periphery. If the cutter teeth have no helix angle (Figure 43A)the tooth rest can be mounted on the table.

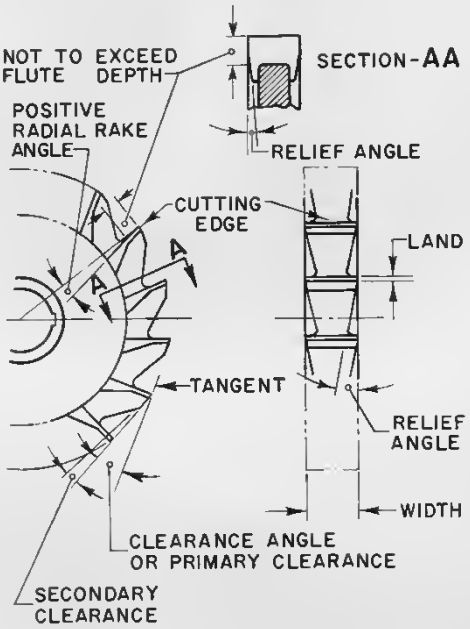


Figure 43A
Side Milling Cutter

After grinding the periphery of the cutter in the regular manner, set up for grinding one side of the cutter in the same manner as described under grinding the face of shell end mills, then grind the other side of the cutter.

This type of cutter often shows a tendency to chatter. To correct this fault, the cutting clearance on the sides of the teeth can be reduced to as low as 1°. Also for a properly ground cutter the teeth on the sides of the cutter should be ground square with the periphery and not to exceed, in length, the flute depth and the remaining part of the cutter tooth should be relieved as shown in section A-A. To accomplish this result, swivel workhead about 3° at the primary setting, when grinding the sides.

Grinding a Staggered Tooth Cutter. Cutters of this type present several problems, so complete instructions are listed in detail.

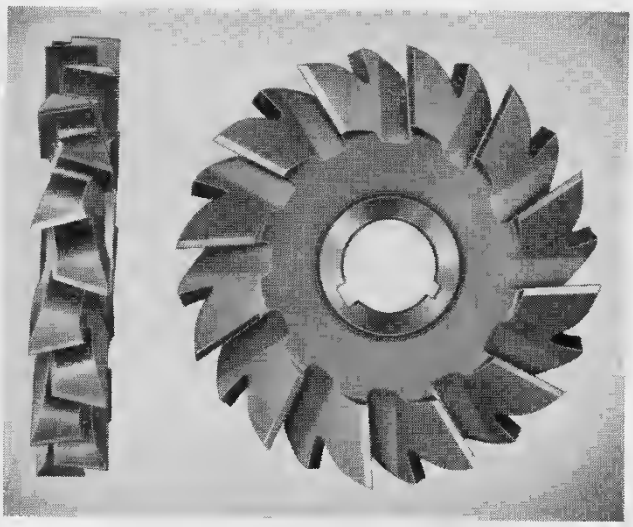


Figure 44A
Staggered Tooth Cutter

Primary Clearance. Contrary to the opinions and practice of many, the primary clearance can be ground on all the teeth in one setting almost as quickly as a straight tooth slotting cutter. Proceed in the following manner for this set-up:

1. Adjust the saddle away from the wheelhead to allow plenty of room for the set-up. Clean the table and bottoms of the right and left-hand tailstocks. Clamp them to the table, with an extra T-bolt between them, and properly spaced for the arbor or mandrel used for the set-up, (Figure 44B)

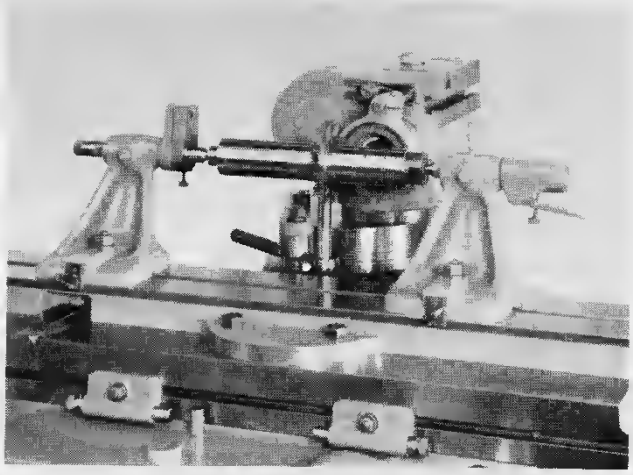


Figure 44B
Set-up for Grinding a Staggered Tooth Cutter

2. Clean the arbor, collars, and cutter hole. Mount them on the arbor, lightly clamp with the nut, and place the assembly between centers.
3. Fasten the wheel mount—collet and flared cup grinding wheel Print No 11Y–120 to the wheelhead spindle.
4. Swivel the eccentric wheelhead 1° from a 90° setting.
5. Check the wheel speed. The belt should be on the high speed pulley (Figure 20A).

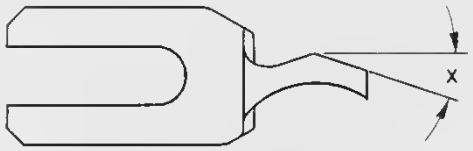
6. Mount the toothrest assembly on the eccentric wheelhead. An inverted "V" type blade is preferred, having an included angle which is at least 10° less than the included angle of the cutter teeth (Figure 45A).

7. Position the high point of the inverted "V" type blade exactly in center of the width of the cutting edge of the grinding wheel and approximately on the same centerline of the grinding wheel spindle.

8. Using the centering gage from the table, adjust the wheelhead vertically until the highest point of the toothrest blade is gage height

9. Traverse saddle toward eccentric wheelhead until one cutter tooth rests on the blade. Lock the table in position.

10. Clamp the clearance setting dog on the arbor.



ANGLE X IS 5°TO 8°GREATER THAN HELIX ANGLE OF CUTTER TEETH

Figure 45A
Tooth Rest Recommended for Staggered Tooth Cutter Set-ups

11. With a cutter tooth resting on the tooth rest, lower the wheelhead until the desired clearance is indicated on the clearance setting dial. Closely spaced teeth may limit the amount of clearance angle obtainable (See step No. 17 page 46).

12. Unlock the table and remove the clearance setting dog.

13. Run through the set-up without grinding. With one hand, traverse the table (using the rear control) and with the other hand hold the arbor just firmly enough to keep the cutter tooth against the tooth rest blade.

14. Start the spindle rotation and stand away from in line of the wheel. For safety, allow the wheel to run about one minute

15. Adjust the saddle until one cutter tooth lightly contacts the wheel. Grind one tooth as the table traverses, for example, from left to right. On the return traverse of the table grind the next tooth of the opposite helix

16. After grinding two teeth of the cutter, check these teeth with an indicator gage. If not the same height, slightly adjust the tooth rest blade toward the high side, and grind next two teeth, repeating process until all teeth check within .0003".

17. If the teeth of the cutter are closely spaced as is the case with a fine tooth cutter, mount wheel Print No. 12Y–155 on the wheelhead, and by using the centering gage on the table, center the wheelhead, for clearance adjust wheelhead up or down as desired, using chart on page 97. Mount tooth rest assembly on wheelhead and adjust tooth rest to height of centering gage from top of table. Continue as outlined in steps Nos. 15 and 16.

Secondary Clearance. Although the table on page 35 recommends secondary clearance angles of 3° to 5°, staggered tooth slotting cutters are an exception to the rule. 20° to 25° is recommended to provide more chip space, since these cutters are particularly effective when milling deep slots, therefore more chip space is needed to prevent 'clogging'. Also provides enough clearance to avoid regrinding the secondary clearance each time the primary clearance is ground. This operation requires two set-ups of a different type.

1a. Change the tooth rest from the eccentric wheel head to the table, using the T-bolt previously placed between the tailstocks. Use the micrometer adjustable tooth rest, and a straight tooth rest blade.

2a. Using the centering gage from the top of the table, place the center of the width of one tooth of the cutter on center with the tailstock centers, mark this tooth.

3a. Rotate the cutter the desired amount of secondary clearance by using the clearance setting dial on the left hand tailstock.

4a. Adjust the tooth rest under or on the side of the marked tooth (step 2a) that was originally on center line.

5a. Swivel the table as much as your judgment dictates to grind a straight land. Swivel right or left, depending upon the helix angle of the tooth to be ground.

6a. Unlock the table and remove the clearance setting dog.

7a. Grind the secondary clearance to about 1/32" width of land.

Note: The importance of grinding the secondary clearance to 1/32" of an inch is that if the cutter is not damaged or worn an excessive amount, the primary clearance can be ground enough to sharpen cutter, without grinding the secondary clearance.

8a. Repeat for every tooth having the same "hand" of helix angle.

9a. Repeat the set-up, with the table swiveled to the opposite direction, for all teeth of the opposite helix angle.

Sides The sides of a staggered tooth cutter should be ground only when desired to reduce its width.

1b. Clean the table and bottom of the workhead. Clamp this unit to the table

2b Mount the cutter on a stud arbor. Equipment of this type should be available for the cutter grinder only.

3b. Use wheel Print No. 11Y–120

4b. Tilt workhead up and with the centering gage from the top of the wheelhead level one tooth in a horizontal plane with the table.

5b. Mount tooth rest on workhead, with the tooth rest blade supporting the leveled tooth to be ground.

6b. Raise or lower the wheelhead to allow the wheel to clear the tooth next to the one being ground

7b. Grind primary clearance, all teeth.

8b. It is advisable to put a relief angle on sides of this cutter as was decribed on bottom of page 43.

9b. For the secondary clearance, tilt workhead up to the desired amount of clearance and repeat steps Nos. 6b and 7b.

Note: The sides of these cutters should be checked, whenever possible, with a flat rubbing plate, coated with redlead, to show the cutter bearing. If properly ground, the bearing will show, on the coated redlead rubbing plate, slightly heavier toward the periphery of the cutter.

Grinding an Angular Cutter. Angular cutters such as angular shell mills, angular arbor type cutters and standard dovetail cutters should be sharpened with a great deal of care, since the angle being sharpened should be held to a very close tolerance. The following instructions will give the operator a true angle and an exact amount of clearance from the cutting edge from the beginning of the angle to the end.

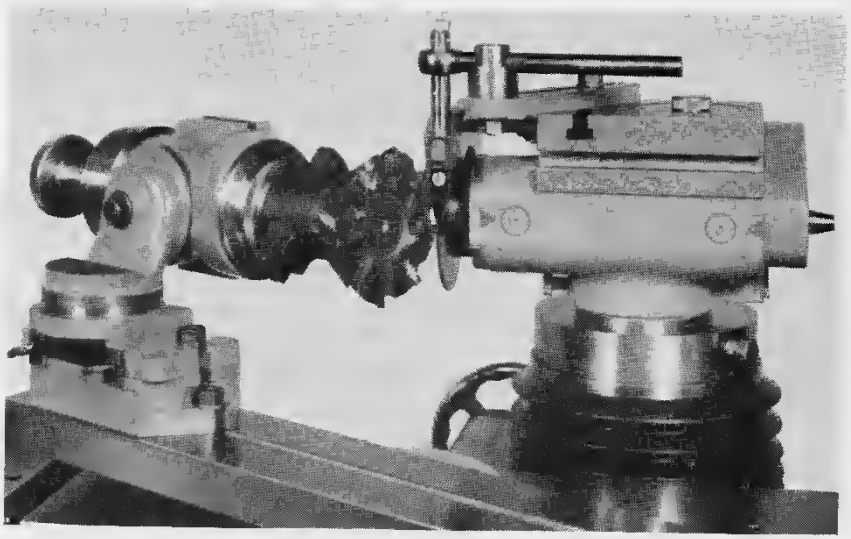


Figure 48A
Set-up for Grinding a 45° Dovetail Cutter

1. Adjust saddle away from the eccentric wheelhead to allow plenty of space for the setup. Clean the table, top and bottom of the raising block and bottom of the universal workhead.

2. Mount raising block with the workhead fastened on top of it (Figure 48A). This will insure the operator a sufficient amount of clearance when sharpening face of cutter.

3. Swivel workhead in the horizontal plane to the angle desired as shown by graduations on the base and lock in position.

4. Mount cutter in workhead.

5. Mount wheel collet assembly and guard, using wheel Print No. 1Y (6″ diam. x 1/8″ x 1 1/4″ hole), on the wheelhead spindle.

6. Center wheelhead using centering gage from the table. Remembering that a raising block was used under the workhead and should also be used under the centering gage to get workhead and wheelhead on the same center.

7. Raise or lower the wheelhead for desired amount of clearance, using chart on page 97.

8. Mount tooth rest assembly on the eccentric wheelhead (Figure 48A).

9. Adjust tooth rest to the height of the centering gage. Using the raising block as described in step No. 6.

10. Traverse saddle toward wheelhead until one cutter tooth rests on tooth rest blade.

11. Grind one tooth and mark so this tooth can be checked. **Note:** Checking should be done very carefully and where angles must be held within plus or minus three minutes an optical comparator should be used.

12. If angle is slightly off, swivel workhead very slightly. As an aid in swiveling workhead, a dial indicator can be mounted on swivel table to indicate amount workhead moves (Figure 25B). Regrind tooth and check again; if tooth is correct, grind remaining teeth.

Grinding Small Diameter Metal Cutting Saws. Metal cutting saws of 8″ diameter or less may be ground without the use of special attachments

The saw may be held by a saw grinding attachment, which may be purchased at extra cost. (See extra cost equipment near end of book). This attachment fits into the workhead, or it may be held on an arbor placed between the tailstock centers (Figure 50A). In either case, the method of grinding is essentially the same as for an ordinary slotting cutter. Use wheel Print No. 11Y–120 when grinding a saw, and lower the wheelhead far enough so the tooth next to the one being ground will clear the top of the wheel. Refer to pages 38-39 for basic instructions

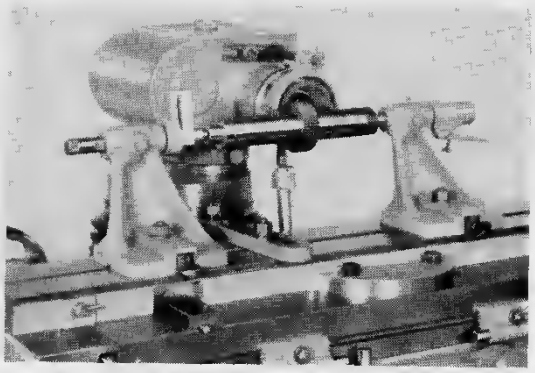


Figure 50A
Set-up for Grinding Several Small Diameter Metal Cutting Saws

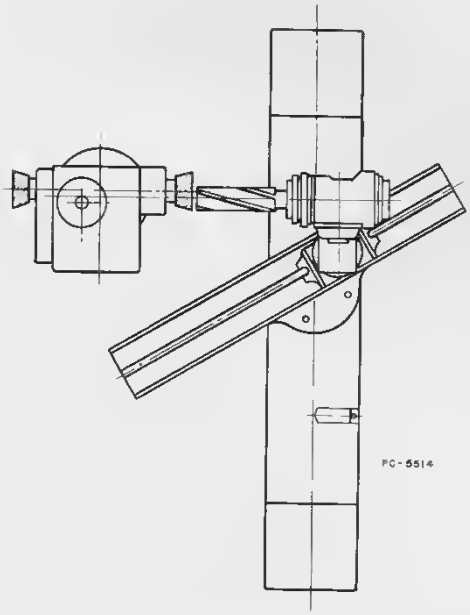


Figure 50B
Set-up for Grinding the End Teeth of Long End Mills

Grinding the End Teeth of Long End Mills. The actual grinding procedure for grinding short and long end mills is the same except end mills which are too long to grind the end of the teeth in the conventional manner may be ground by swiveling the table illustrated in Figure 50B. Exceptionally long flute lengths may be accommodated in this manner, as compared to approximately 4¼″ with the regular table setting and 7½″ with the table swiveled 180°.

Grinding a Helical Cutter. The set-up for grinding a helical cutter having a steep helix angle is listed in detail because it is different than any other type (Figure 51A).

1. Fasten a 6" diameter disc wheel to the end of the spindle.
2. True it with the diamond truing attachment (Figure 28C).
3. Swivel the wheelhead to the desired clearance angle. (See table, page 52. For example, if the cutter has a 40° helix, and you want to grind a 5° clearance angle, swivel the wheelhead to 3¼°.)

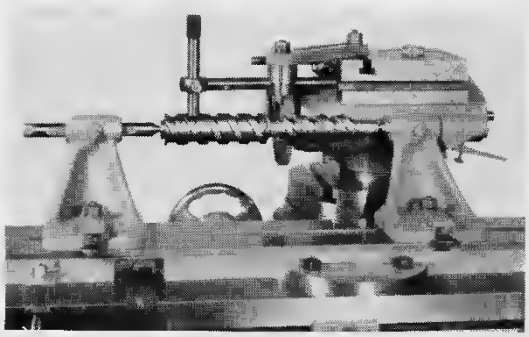


Figure 51A
Grinding the Periphery of a Helical Cutter

4. Insert the shank end of the cutter in the taper hole of the *guide, and place both between the tailstock centers.
5. Place the centering gage on the table and adjust the column to zero. Move the saddle towards the wheel to bring the cutter in position.

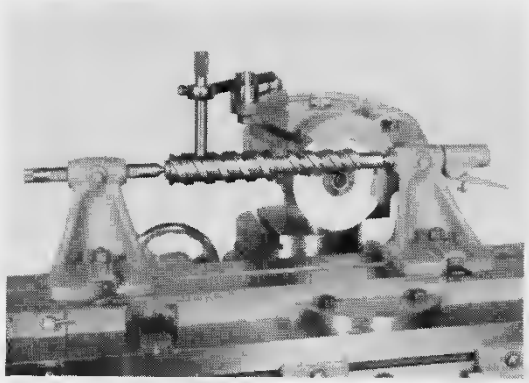


Figure 51B
Grinding the Face of a Helical Cutter

6. Fasten the tooth rest holder to the top of the eccentric wheelhead, with the stem of the holder in the slot of the guide. Any piece of cold rolled steel the same diameter as the width of slot in the guide may be used; or the tooth rest blade may be used if a little care is exercised.
7. Adjust the wheel to the work and grind

There should be ample clearance between the ends of the cutter teeth and the end of the guide grooves to allow the tooth rest to clear the groove when indexing to the next tooth.

*Note: A guide of the same helix angle, lead, and "hand" as the cutter, and slightly longer should be provided for grinding each helical cutter.

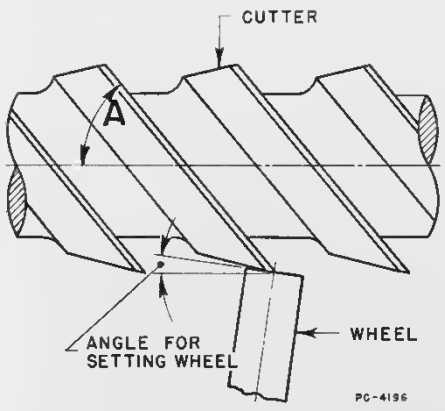


Figure 52A
Angular Setting of Wheel for Helical Cutters

ANGLE FOR SETTING WHEEL TO OBTAIN CLEARANCE ANGLE OF 3° TO 10° ON HELICAL CUTTERS

Helix Angle "A"	CLEARANCE ANGLE DESIRED							
	3°	4°	5°	6°	7°	8°	9°	10°
30°	1½	2	2½	3	3½	4	4½	5
35°	1¾	2¼	3	3½	4	4½	5¼	5¾
40°	2	2½	3¼	4	4½	5¼	5¾	6½
45°	2	2¾	3½	4¼	5	5¾	6½	7¼
50°	2¼	3	3¾	4½	5½	6¼	7	7¾
55°	2½	3¼	4	5	5¾	6½	7½	8¼
60°	2½	3½	4¼	5¼	6	7	7¾	8¾
65°	2¾	3¾	4½	5½	6½	7¼	8¼	9
70°	2¾	3¾	4¾	5¾	6½	7½	8½	9½
75°	3	3¾	4¾	5¾	6¾	7¾	8¾	9¾

Grinding a "V" Thread Type Tap. The set-up for grinding a "V" thread tap illustrated in Figure 52B is listed in detail because it is sharpened differently than the cutting tools discussed on previous pages.

1. Rotate the lower swivel so as to position the eccentric wheelhead in the extreme front position, rotate the eccentric swivel so centerline of spindle is perpendicular to T-slot of table and lock both swivels in position (Figure 22C).

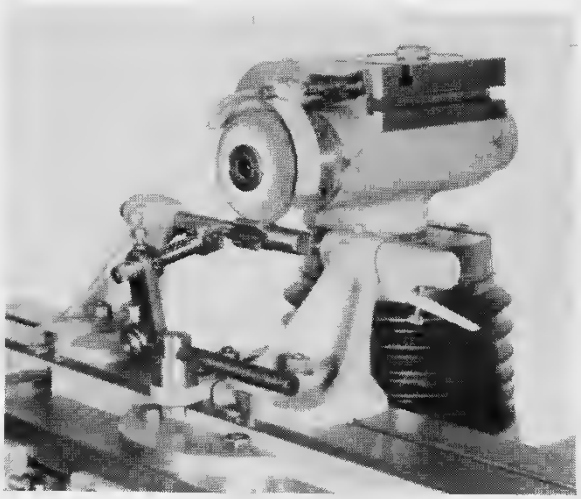


Figure 52B
Grinding a "V" Thread Type Tap

2. Adjust the saddle away from the wheelhead to allow plenty of room for the set-up. Clean the table and bottoms of the right and left-hand tailstocks. Clamp them to the table, with an extra T-bolt between them, and properly spaced for the tap to be ground. Small taps may be held by collets or a chuck in the Universal Workhead.
3. Place the tap between centers (or in workhead).

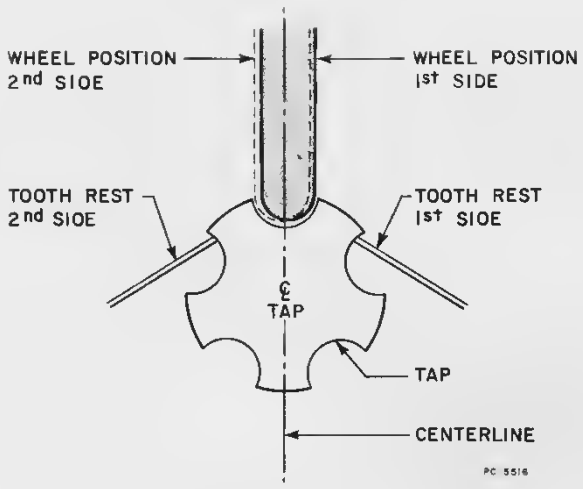


Figure 53A
Illustration Showing Position of Toothrest and Grinding Wheel When Sharpening a "V" Thread Tap.

4. Fasten the universal tooth rest assembly to the table with the square end blade against the back of the tooth to be ground. **Note:** When grinding a tap, the tooth rest set-up will be more rigid and simplified if it is elevated by placing it on a 2" raising block. (Obtainable at extra cost.)

5. Mount wheel collet assembly and guard to the spindle housing, using wheel Print No. 1Y, thickness of wheel to be smaller than width of flute of the tap to be ground (Figure 53A).

6. Dress the wheel with a hand dressing stick so shape will be the same as that of the flute of the tap (Figure 53A).

7. Adjust saddle to position centerline of tap, to approximately the same centerline as the grinding wheel (Figure 53A).

8. Grind one side of flute making sure not to destroy the original manufacturer's shape of the flute. Redlead can be used as an aid in determining if tap and wheel are positioned correctly to grind one side of the flute as shown in Figure 53A Very little stock removal is necessary to sharpen this tap **Note:** Taps are normally sharpened by grinding the lead, the procedure outlined above should only be used if absolutely necessary.

Grinding an Acme Thread Tap or Hob. The set-up for grinding an Acme Thread Tap or Hob is essentially the same as grinding a "V" Thread Tap as will be noted below. However, since these taps or hobs are straight and helical tooth, having straight radial sides, the setup is slightly different than the setup for the "V" thread tap. The various steps to make this setup are as follows: **Note:** To produce accurate results in grinding, the backs of the teeth should be ground before grinding the faces, for the same reason as described under instructions for "Grinding a Formed Relieved Cutter" (pages 56-59).

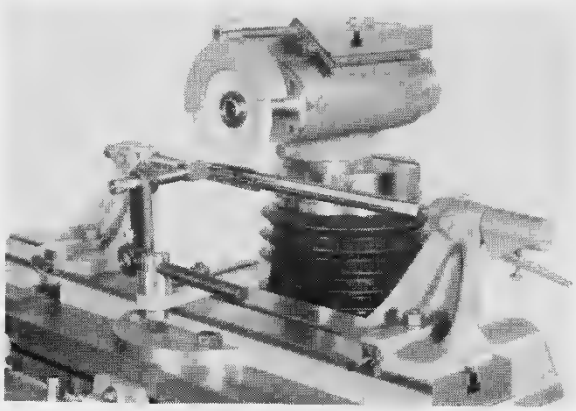


Figure 54A
Grinding an Acme Thread Tap

1. Rotate the lower swivel so as to position the eccentric wheelhead in the extreme front position, rotate the eccentric swivel so centerline of spindle is perpendicular to T-slot of table and lock both swivels in position (Figure 22C).

2. Adjust the saddle away from the wheelhead to allow plenty of room for the setup. Clean the table and bottoms of the right and left-hand tailstocks. Clamp them to the table, with an extra T-bolt between them, and properly spaced for the length of tap to be ground. Small straight fluted taps may be held by collets or a chuck in the Universal Workhead

3. Mount wheel collet assembly and guard. Using a flat wheel which when trued to 12½° on one side, to give single line contact, will fit in helical groove of taps or hobs. Use wheel print No. 12Y-155 for straight groove taps or hobs.

4. True the grinding wheel for helical groove taps or hobs to a 12½° angle. This may be done two ways. Swivel the eccentric wheelhead to 77½° and with the diamond bracket and diamond, true the wheel. Touch up the sharp corner of the wheel with a hand dressing stick

5. Mount the tap between centers or in the workhead, hobs can be mounted on arbors. In the case of the helical fluted taps or hobs, a master blank

having the same lead as the tap, hob or cutter must also be mounted between centers. Usually this master will be mounted right on the shank of the tap or on the same arbor as the hob or cutter. (Figure 55B).

6. Fasten the universal tooth rest assembly to the table with the square end blade against the back of the tooth to be ground. **Note:** When grinding a tap or hob, the tooth rest setup will be more rigid and simplified if it is elevated by placing it on a 2" raising block. (Obtainable at extra cost.) In the case of helical fluted taps or hobs, the universal tooth rest is mounted on the top of the wheelhead with the tooth rest blade against one tooth of the master (Figure 55B).

7. Adjust saddle in toward the eccentric wheelhead to position tap or hob.

8. Center the wheel, for straight groove taps or hobs. Place a straight-edge across the face of the wheel, and line up with tailstock centers. A simple gage can be made for this operation at little expense (Figure 55A). For helical groove taps or hobs adjust saddle and universal toothrest so grinding wheel will match previously ground tooth face.

9. First take a trial cut. A small amount of red lead smeared across the face of the tooth will help you determine whether or not the wheel is cutting the full width of the face of the tooth. Adjust the hob tooth to the wheel with the micrometer tooth rest adjustment, and grind.

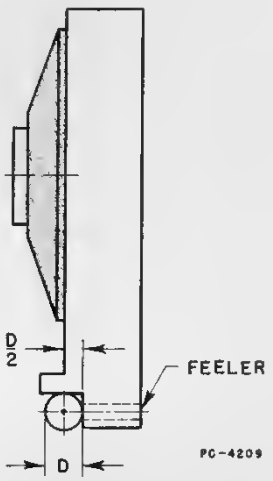


Figure 55A
Gage for Centering Face of Wheel with Center of Work

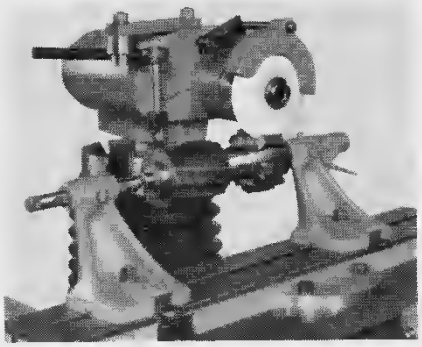


Figure 55B
Grinding Helical Groove

10. After grinding, test the hob teeth with an indicator to see that they have been ground radially (Figure 56A).

Important: The teeth must be ground radially in cutters of this type, or the tooth form will be changed. A simple and effective means of testing is shown in Figure 56A. The block is exactly 5⅜" high, the same height as the tailstock centers. Set the indicator dial to zero when indicating

this block, then remove the block and turn the cutter until the outer edge of the tooth touches the indicator pointer and registers zero on the dial. Then move the indicator straight in towards the center of the cutter, and note the reading. If the tooth is ground radially, the indicator will remain at zero.

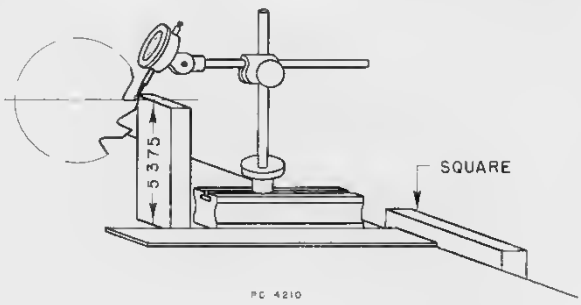


Figure 56A
Testing the Accuracy of Grinding a Radial Tooth Form Cutter

Grinding Form Relieved Cutters. The only correct way to sharpen form relieved cutters is to grind the *face* of the teeth (Figures 56B and 57B). To accomplish this result, it is necessary that the feed or adjustment of the cutter to the grinding wheel should be a *rotary or circular adjustment*, as provided for in the Cincinnati Gear Cutter Sharpening Attachment.

When grinding a new cutter for the first time, it is sometimes necessary to grind the *backs* of the teeth before grinding the cutting face. This extra operation need only be done once, but it is necessary because the pawl locates from the back of the teeth, and if they are all ground uniformly, more accurate results can be obtained.

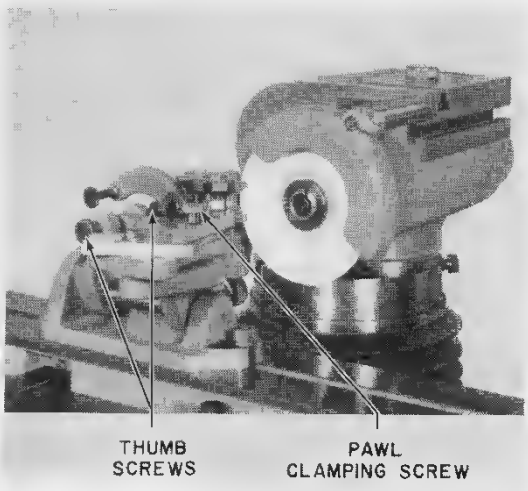


Figure 56B
Grinding the Faces of the Teeth on a Form Relieved Cutter

To set up for the first grinding operation of an ordinary formed relieved cutter, proceed as follows: (See Figure 57C).

1. Depending on the diameter of the cutter adjust the lower swivel (Figure 22C) so as to position the eccentric wheelhead in a position toward the slide table.
2. Swivel the eccentric wheelhead to a 90° setting.
3. Clamp the attachment on the table, to the left of the wheel, with the pawl side *away* from the wheel. See that the upper swiveling part of the attachment is set to zero on the degree readings.

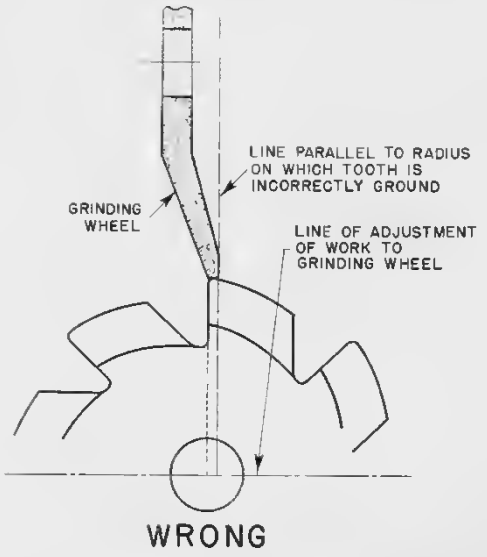


Figure 57A
The Wrong Way to Grind a Radial Form Relieved Cutter. The face of the tooth is ground in a plane parallel to the radius, deforming the tooth profile

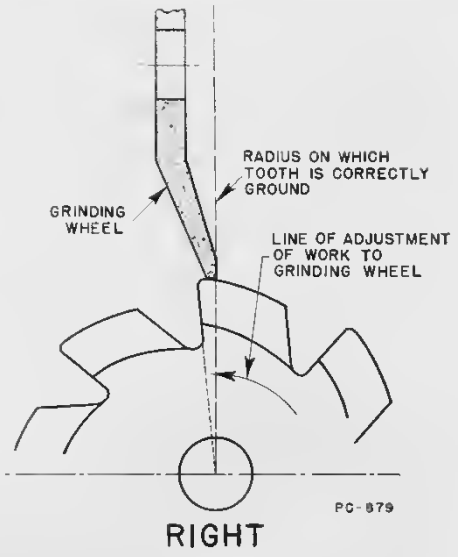


Figure 57B
The Correct Way to Grind a Radial Form Relieved Cutter. The face of the tooth is ground in a radial plane

4. Mount wheel collet assembly and guard using wheel print No. 12Y-155.

5. Place the cutter on the stud in the reverse position, so that the back of the tooth can be ground.

6. Set the centering gage on top of the wheelhead and adjust the head vertically until the cutter and gage are about central. Remove the gage and adjust the saddle in or out, and at the same time rotate the cutter by hand on the stud to bring the back of the tooth in the same plane with the face of the wheel.

7. Place the edge of the pawl on the face of the tooth being ground (Figure 57C) and clamp in place by tightening pawl clamping screw (Figure 56B).

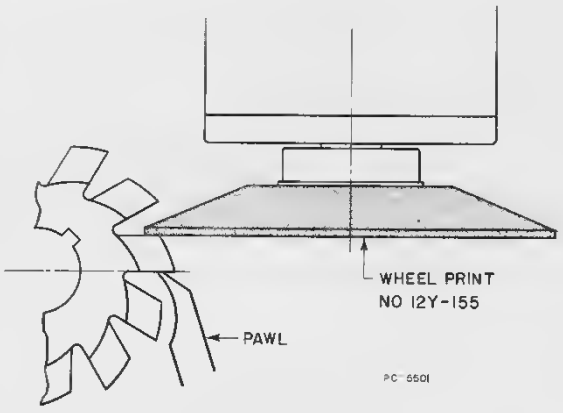


Figure 57C
Grinding the Backs of the Teeth of a New Gear Cutter

8. To index for grinding the back of the next tooth, traverse the table to the left, moving the cutter away from the wheel. Index the cutter so the swivel pawl will rest against the next tooth. Hold it lightly against the pawl with one hand while grinding.

   Due to deformations set up in hardening, the amount ground off one tooth may be greater than the next tooth, but there will then be a uniformity between the back of the teeth (the locating side for grinding) and the face of the teeth. To continue with the sharpening operation (radial tooth cutters only):

9. Swivel the attachment centering gage up to the top of the attachment, and rotate the cutter by hand on the stud to bring the face of one tooth against the gage. Adjust the pawl to contact the back of the tooth just ground, and then swing the gage out of the way (Figure 56B)

10. Adjust the saddle to bring the face of a tooth in line with the face of the grinding wheel. Do not re-adjust the saddle while the cutter is being ground, except to compensate for wheel wear. Wheel wear should be compensated for after each complete revolution of the cutter.

11. Loosen one thumb screw and tighten the other one to rotate the face of the tooth towards the grinding wheel (Figure 56B).

12. Grind one tooth, move the attachment away from the wheel by means of the table motion, index to the next tooth, grind, and so on.

13. If cutter wear has not been removed, re-set thumb screws and repeat the grinding operation.

   Checking—These cutters can be checked right on the attachment or between centers on an arbor, using a dial indicator. It is important that all of the teeth be concentric within .001 of an inch.

If the teeth are provided with rake, of course they can not be ground radially, but must be ground in a plane tangent to the base circle, as shown in Figure 59A Line up the point of one cutter tooth with the attachment gage, as before, swivel the table to the degree of rake angle, adjust the saddle to bring the face of the tooth in line with the face of the wheel, and grind. (Also see discussion on page 34). If cutter wear has not been removed, adjust the saddle towards the wheel to compensate for wheel wear, and repeat the operation

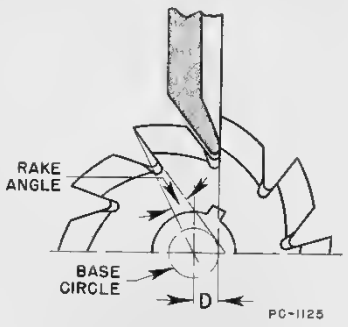


Figure 59A
Formed Relieved with Undercut Teeth

Roughing formed relieved cutters are sometimes made with alternate right and left side rake on the teeth to produce a better cutting action. These stagger tooth cutters can be ground by using the standard gear cutter grinding attachment. Remembering the backs of the teeth must be ground on new cutters, before grinding the cutting edge, see pages 56, 57 and 58 When setting up, proceed as for the regular cutter, then tilt the upper part of the attachment the amount of the side rake, which is usually seven to ten degrees. Set the gage to the outer edge of the tooth and clamp the pawl in position to rest on the back of the teeth. Adjust the saddle until the edge of the wheel just touches the outer edge of the tooth, then proceed to grind every other tooth. For the second operation, tilt the upper part of the attachment the same amount in the opposite direction, touch up the outer edge of the tooth with the wheel, and proceed to grind

Grinding Large Diameter Face Mills. Large diameter face mills which are too large to sharpen on the Universal Workhead can be sharpened on the Large Face Mill Grinding Attachment. To set up this attachment for grinding a face mill, either with a cup wheel or disc wheel, proceed as follows:

Grinding the Face

1. Remove the taper setting gage blocks, loosen the table clamping screws and turn the disengaging pin handle on front of the table, one-half turn (Fig. 25A). Swivel the table 180 degrees and lock in position.

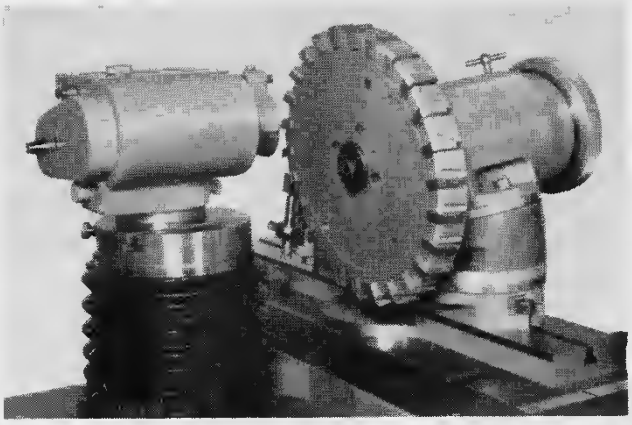


Figure 60A
Grinding the Face of a Large Diameter Face Mill

2. Depending on the diameter of the cutter, adjust the lower swivel (Figure 22C) so as to position the eccentric wheelhead in a position toward the slide table (Figure 60A).
3. Swivel the eccentric wheelhead one degree from a 90° setting.
4. Clean the top of the table and the bottom of the attachment, mount attachment and clamp midway between the ends of the table.
5. Swivel the attachment spindle housing to some convenient position and mount face mill (see Figure 60B for suggested method).
6. Swivel the spindle housing to match the O-line on the upper scale of the intermediate plate, and clamp. Then swivel the housing and plate as a unit to match the O-line of the lower scale with the base, and clamp. The attachment spindle is now in a horizontal plane, and at right angles to the cutting edge of the wheel as shown in step No. 1 (Figure 61A).

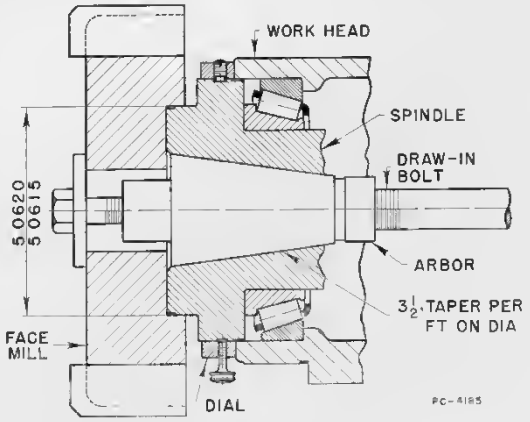


Figure 60B
Face Mills fitting the National Standard Milling Machine Spindle Nose center on the attachment spindle. Other face mills can be centered on the 1½" diameter end of arbor either direct or by adapter bushings. Adapter bushings are not furnished with attachments.

7. To set the attachment to the desired clearance angle (for example, 5 degrees).

(a) Loosen the bolts through the spindle housing, swivel it 5 degrees to the left and clamp

(b) Loosen the bolts through the intermediate plate, swivel the housing and plate 5 degrees to the right, and clamp (Fig 61B)

(c) To set the attachment for the desired secondary clearance angle (for example 15 degrees) follow steps (a) and (b) using 15 in place of 5 degrees (Figure 61C).

8. Mount wheel collet assembly and guard using wheel print No. 11Y-120

9. Place the centering gage on top of the wheelhead. Level the cutting edge of one tooth in a horizontal plane.

10. Clamp the tooth rest on the table and adjust it to suit, bringing the finger up under the tooth to be ground.

11. Bring the cutter to its approximate grinding position in front of the wheel and adjust the column so that the wheel will clear the tooth next to the one being ground.

12. Loosen the attachment spindle locking screw, set the dogs on front of the table and grind

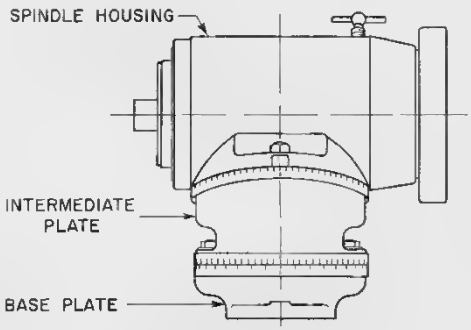


Figure 61A
Step No. 1

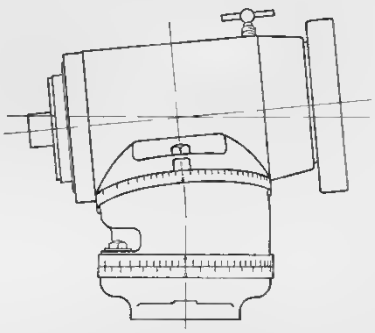


Figure 61B
Step No. 2

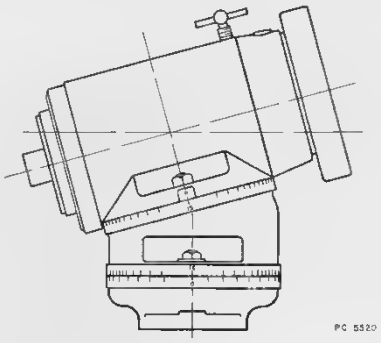


Figure 61C
Step No. 3

Grinding the Periphery.

13. Change the tooth rest assembly from the table and locate on wheelhead, using the offset tooth rest blade (Figures 62A and 62B)

14. Swivel the attachment so the centerline of the attachment spindle is parallel to the centerline of grinding wheel spindle. That is the face of the milling cutter is parallel to the face of the grinding wheel.

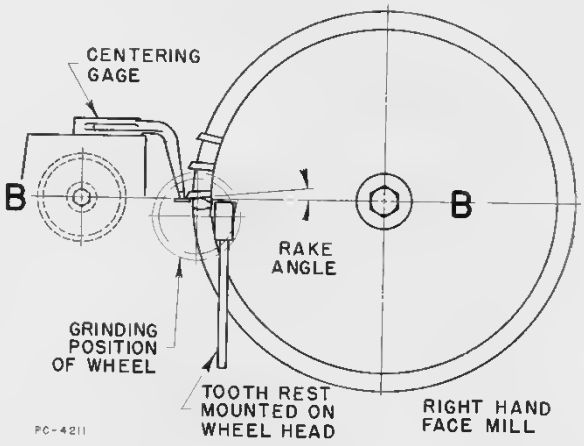


Figure 62A
Set-Up for Grinding the Periphery of the teeth of Face Mill.

15 Place the centering gage on top of the wheelhead. Adjust the column and saddle to bring the center of the cutter in line with the point of the gage

16. Swivel the attachment so the centerline of the attachment spindle is perpendicular to the centerline of grinding wheel spindle (Figure 62B)

17. Position the toothrest blade in front of the grinding wheel. Using the centering gage from top of wheelhead adjust toothrest to gage height. Clamp in position

18 Run a cutter tooth over the toothrest blade, coated with redlead, to establish a contact point. Re-adjust the toothrest blade so contact point is exactly on center of the width of the grinding wheel cutting edge

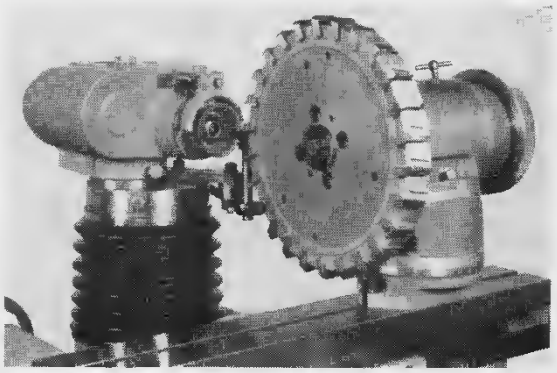


Figure 62B
Grinding the Periphery of the Teeth on a Large Diameter Face Mill

19 Place a cutter tooth on the toothrest blade, lock table traverse, set vertical handwheel dial to zero; lower wheelhead holding cutter tooth on toothrest blade until desired cutter clearance is reached.

20 Unlock table traverse and proceed to grind.

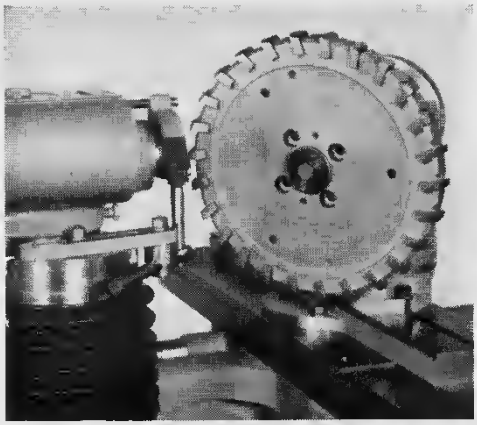


Figure 63A
Grinding the Corners of the Teeth of a Large Diameter Face Mill

Grinding the Corners.

21. The tooth rest setting and the general procedure is similar to that outlined for grinding the corners on shell end mills.

22. Loosen the bolts thru the intermediate plate and swivel the housing and plate 45 degrees, using in this case, 5 degrees on the lower scale of the plate as a starting point.

23. Loosen the bolts thru the spindle housing and swivel it 5 degrees to the left. Re-set and grind, similar to the previous operations.

Cylindrical Grinding. The Cylindrical Grinding Attachment can be used for all types of straight or taper cylindrical grinding; such as reamers, lathe centers, mandrels, tap or drill shanks, and for facing operations, such as cutter hubs, gear shaper cutters, collars, nuts, etc. Production, tool room or experimental lot sizes may also be economically ground with the Cylindrical Grinding Attachment, if dry grinding is permissible. *Note:* Machines designed for the use of coolant, see pages 123 to 134

This attachment is designed to rotate the work between a live or dead center in the headstock and tailstock; in a chuck, or on a stud. The electrical extension cord of this attachment can be plugged into a receptacle built into the left side of the machine base, right or left-hand rotation may be selected as desired through a two-way switch built into the push button station located on left side of the base of the machine (Figure 17B).

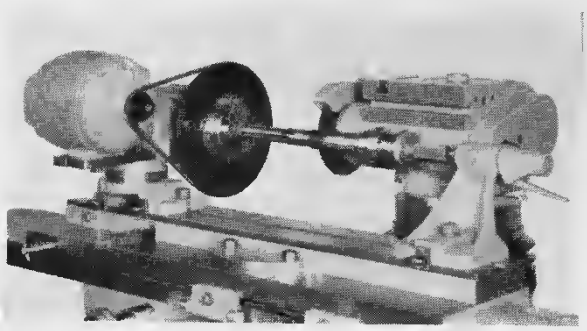


Figure 64A
Grinding a Shoulder Using the Cylindrical Grinding Attachment

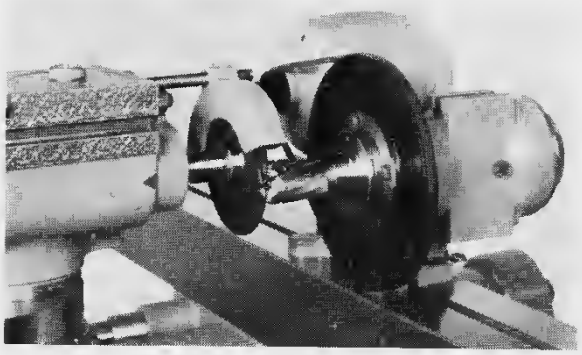


Figure 64B
Cutting Off the Damaged End of a Helical End Mill

To set up for cylindrical grinding work which can be held between centers (Figure 64A), proceed as follows·

1. Place the centering gage on the table, adjust the column to the zero mark, and clamp in place

2. Fasten the workhead to the table, and lock the workhead spindle in position with the knurled thumb screw.

3. Place the pulley on the workhead dial, and fasten securely with the two screws and clamps provided

4. Loosen the headless set screw through the workhead dial, allowing the pulley and dial to rotate freely on the spindle

5. Place the workhead motor and endless belt in position, and clamp securely.

6. Fasten the driving dog in position on the pulley.

7. Set the table to zero or to a desired taper.

When grinding the sides of thin cutters, saws, washers, etc., it is necessary that the workhead spindle and work rotate together, since the chuck which holds the work is driven by the spindle. To accomplish this result, loosen the knurled thumb screw through the workhead casting and tighten the headless set screw through the workhead dial, which allows the spindle to rotate with the pulley.

Use the differential table traverse crank for finishing. For roughing, disengage the differential unit and use the front or rear table traverse knobs.

The pulley on the workhead rotates at 360 rpm if the standard 1750 rpm work head motor is used. Use any desired wheel.

Internal Grinding. This attachment is ordinarily used for grinding holes in cutters, jig bushings, arbor collars, etc., and is generally used in conjunction with the Cylindrical Grinding Attachment (Pages 64 and 65) To set up, proceed as follows:

1. Remove both wheel guards, wheel guard holders and grinding wheels.

2. On the left-hand side of the wheelhead, screw threaded stud in tapped hole furtherest from center line of spindle This hole is normally used for the wheel guard holders

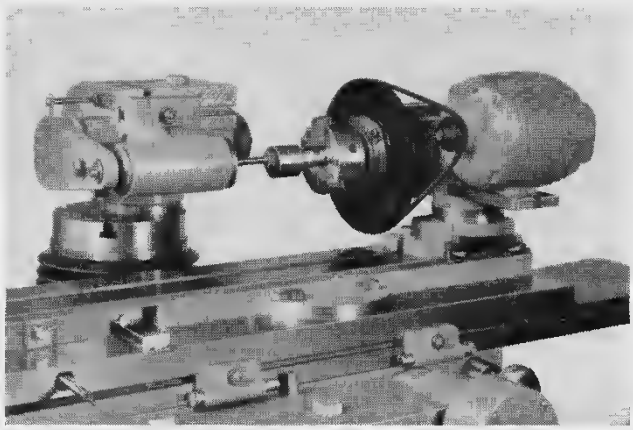


Figure 66A
Internal and Cylindrical Grinding Attachments
Grinding a Straight Hole

3. Fasten the driving pulley on the left hand end of the wheel spindle.

4. Place the attachment on front of the eccentric wheelhead, place the belt over the pulleys, and bolt the attachment in place

5. Mount belt guard. Guard is held on machine by stud (Step No. 2) and knurled knob shown in Figure 66A.

6. Place the centering gage on the table and adjust the column to zero.

The attachment spindle is driven by a positive drive belt from a gear tooth pulley mounted on the grinding wheel spindle, providing approximately a 23,000 rpm for small internal grinding wheels. For roughing, use the rear

knob control. For finishing, use the front table feed control, and set the table dogs. Holes up to 3″ long can be ground with this attachment

The best results will be obtained when the grinding wheelhead has been adjusted vertically to center the attachment spindle with the work This may be done with the aid of the centering gage, as shown in Figure 27A. The wheel should grind on the side of the hole towards the front of the machine To obtain accurate work, align the workhead spindle parallel to the top of the table and parallel to the table traverse, using an aligning bar and an indicator gage on a stand. The best finish will be produced by taking light cuts of about .0005″ per pass.

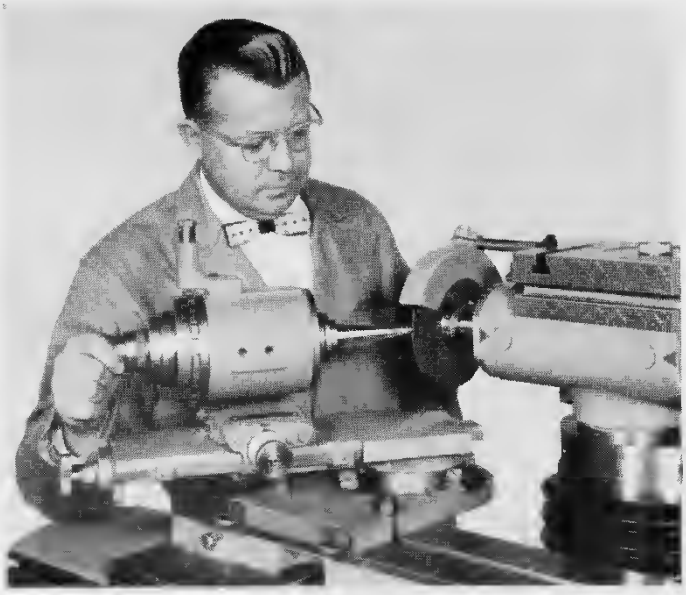


Figure 68A
No. 1 Radius Grinding Attachment Set Up for Grinding a Die-Sinking Cutter

No. 1 Radius Grinding Attachment. For quickly and accurately sharpening small ball-end cutters, double-end cutters, and die-sinking cutters having straight or helical flutes With the addition of motor drive parts, it may be used for cylindrical grinding straight or taper tracer fingers for die-sinking machines and many other parts

There are two slides, each having a convenient micrometer adjustment for the purpose of setting the cutter to the desired radius The bracket bolted to the machine table contains an anti-friction pivot upon which the attachment can be swiveled 360 degrees. The base of the fixed bracket is equipped with movable stops, having screw adjustment to accurately limit the amount of swivel motion of the attachment.

Taper collets, to be inserted in the taper hole of the spindle, are available for grinding taper shank cutters, while straight shank cutters are ground with the aid of adapters and sleeves (Figures 69B and 69C). A stop collar device shown assembled to the sleeves in the two illustrations, is to expedite the quick removal of small cutters for inspection. When replaced for additional grinding they are in exactly the same position as before.

The index plate at the rear of the workhead spindle has 24 notches. With this device, the attachment will handle straight fluted cutters having 1 2, 3, 4, 6, 8, 12 and 24 flutes, without the necessity of a tooth rest However

Figure 69A
Motor Drive Equipment for Cylindrical Grinding Operations. Convenient for Grinding Tracer Fingers

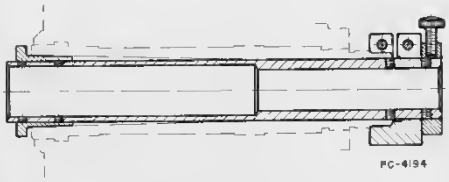


Figure 69B
Equipment for Grinding Large Straight Shank Cutters

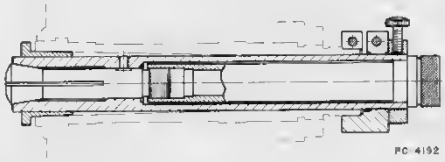


Figure 69C
Equipment for Grinding Small Straight Shank Cutters

it must be remembered, that if there is any irregularity in the spacing of the teeth of the cutter, the universal tooth rest must be used. When grinding cutters with helical flutes, the universal tooth rest supplied with the machine must be used

General Specifications

Capacity—*Maximum diameter cutter—4″
Spindle nose to setting gage—4½″
*Will grind radii of—0 to 2″
Taper in spindle—No. 12 B&S. or No. 5 Morse.
Maximum diameter straight shank—1¼″

Net Weight, approximate—98 lbs.

Standard Equipment—The No. 1 Radius Grinding Attachment is shown in the illustration (page 68), completely assembled. Standard equipment supplied with the attachment includes two centering gages and set of wrenches

Set-Up Suggestions. Use the 2″ spindle extension (item No. 11 page 9) and wheel Print No. 1Y, (6″ diam. x ⅛″ face x 1¼″ hole). The wheel is an important factor, and for best results it should be fine grained and hard enough to hold a sharp corner.

*Note: Capacity of 4″ diameter cutter and 0 to 2″ radius are for newer design attachments. Those having Serial Nos. IDGBIM- , or numbers such as A41M336500-1, have capacities of 3″ diameter cutter and 0 to 1½″ radius

Note: Collets supplied as standard equipment with the machine, pages 8 and 9, cannot be used with this attachment

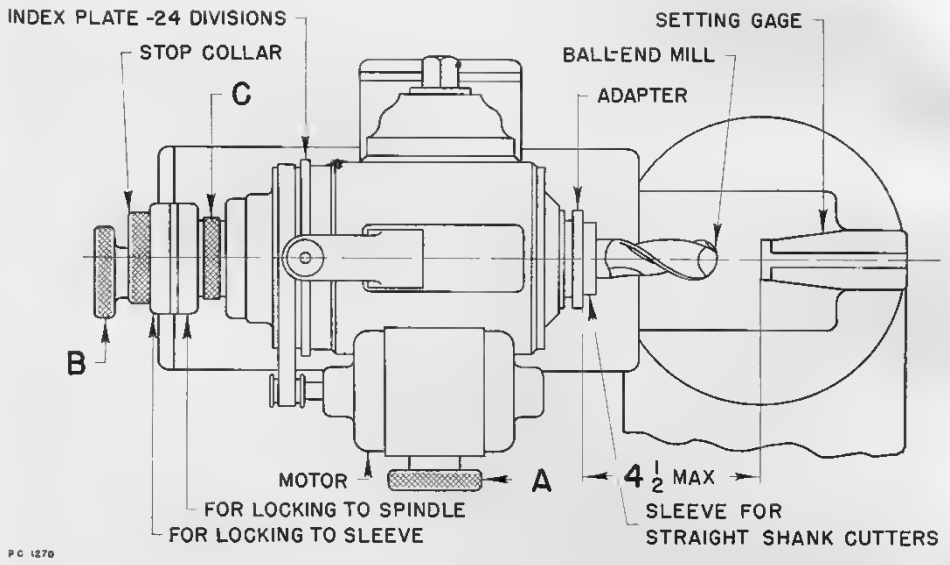


Figure 70A
Outline Drawing of No. 1 Radius Grinding Attachment, Arranged for Power Drive

Ball End Cutters. When setting up the attachment for grinding cutters of this type, adjust knob "B" to bring the end of the cutter against the setting gage (Figure 70A). Set the dial to zero. The attachment is fitted with a stop for the zero setting of the cross slide Set the slide to the positive stop or zero position by adjusting knob "A", and lock in position. The center of the cutter is now in line with the pivot point, and set for zero radius Remove the setting gage and adjust knob "B" to the desired radius. For example, if a ball end is to be ground on a 1" diameter cutter, adjust the knob to bring the end of the cutter .500" beyond the pivot point *Knob "A" must remain at the zero setting.*

Grinding a Radius. To grind a radius on the corner of a cutter, first make the preliminary settings as required for grinding ball end cutters; that is adjust knob "B" to bring the end of the cutter against the setting gage and adjust knob "A" to bring the cross slide against its stop. Then set the two slides for the grinding operation. See example on page 71. The Nos. 1 and 2 Radius Grinding Attachments are both set up in much the same manner

Suppose we assume a ¼" radius on a 1¼" cutter.

(a) Adjust knob "B" to the desired radius, in this case .250"
Note: Knob "B" is always adjusted an amount equal to the radius to be ground.

(b) Adjust knob "A" .375", which will bring the outside edge of the cutter .250" from the pivot point (formula No. 1)
Note: The amount knob "A" is adjusted depends upon the diameter of the cutter.

The amount of adjustment for knob "A" may be calculated from the following equation:

Formula No. 1

$$\text{Adjustment of knob "A"} = \frac{\text{Cutter diameter}}{2} - \text{required radius}$$

Radii may also be ground on cutters from *4" to 7½" diameter, but the minimum radius is limited. It may be calculated in this manner:

Formula No. 2

$$\text{†Minimum radius} = \frac{\text{Cutter diameter}}{2} - 2$$

To grind larger radii on cutters greater than *4" diameter, calculate the adjustment for knob "A" from the following formula:

Formula No. 3

$$\text{†Adjustment of knob "A"} = 2 - (R - r)$$

where R = required radius
r = minimum radius calculated from Formula No. 2.

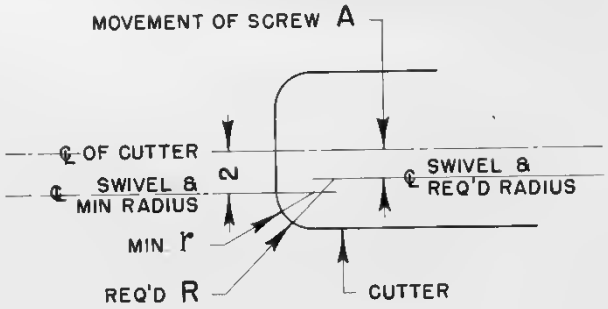


Figure 71A
Pictorial Presentation
of Radius Formulae

Notes:

*See footnote page 69 for capacity of old design attachments.

†The constant 2, in formula Nos. 2 and 3, must be changed to 1½ when making calculations for old design attachments. Serial No. IDGB1M- , or numbers such as A41M 336500-1.

No. 2 Radius Grinding Attachment. This attachment is designed for grinding radii (90 degree arc) on the teeth of shell end mills, face mills and similar cutters. It has a capacity of 0 to 12″ diameter cutters, and will grind radii of 0 to 1″. However, the skilled operator can grind larger radii by adjusting the attachment slides beyond the range of the micrometer. The cutter can first be ground on its diameter, while mounted in the attachment as illustrated here, and then follow with the radius and face grinding operation in one pass. In this way, an accurate radius and a perfect blend will be obtained. Assuming that we are going to grind a ¼ inch radius on a 6″ shell end mill, proceed as follows:

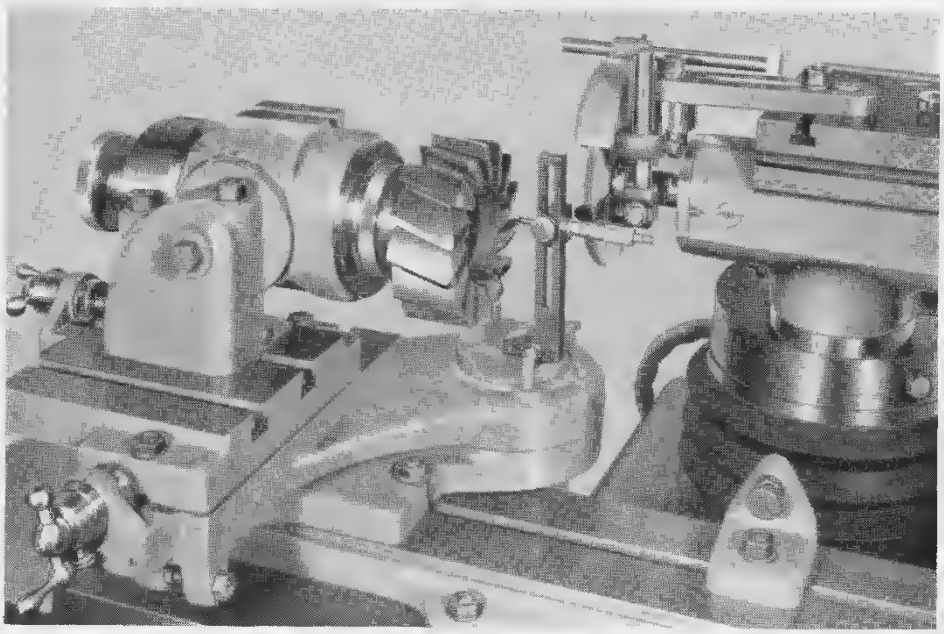


Figure 72A
Corner Radius being Ground on a Shell Mill using the No. 2 Radius Grinding Attachment.

1 *Mounting Grinding Wheel.* Fasten a 2″ spindle extension on spindle. Mount grinding wheel on end of spindle extension, use wheel Print No. 1Y (6″ diam. x ⅛″ face x 1¼″ hole). Fasten proper grinding wheel guard in position. Change tooth grip belt to inner pair of step pulleys. Fasten diamond bracket to table. Raise or lower wheelhead until diamond is on center, start machine and true grinding wheel. If wheel has a tendency to burn work after truing with a diamond, dress lightly with a hand dressing stick.

2. *Mounting Attachment and Cutter.* Stop machine and wipe grit from table surface. Mount radius grinding attachment on left end of table with standard work head housing fastened in horizontal (zero) position. Fasten cutter securely in work head housing with draw-in bolt. The T-slot nearest the grinding wheel is for small diameter cutters while the other T-slot is for large diameter cutters.

3. *Centering Cutter.* Position attachment so face of cutter is toward wheelhead. Using the standard centering gage from top of wheelhead, raise or lower wheelhead until pointer on center gage is approximately in center of cutter. Position center gage so pointer contacts corner of cutter tooth. Turn pointer around (180°) and move center gage so pointer contacts corner of cutter tooth directly opposite the tooth previously gaged. By slightly turning cutter and raising or lowering the wheelhead it is possible to get the two teeth the same height from machine table and on center with the grinding wheel spindle. This is necessary and important because the amount of clearance is computed from this setting. Lock screw on rear side of workhead so cutter setting will not be disturbed.

4. *Selection of Clearance Angle.* Select proper clearance angle. (Refer to table, page 97). Example: To grind a 5° clearance with a 6″ diameter wheel, lower the wheelhead .261″. This means that the center of the grinding wheel is .261″ below the cutting edge of the cutter and the arc ground behind the cutting edge will be equivalent to a 5° clearance angle.

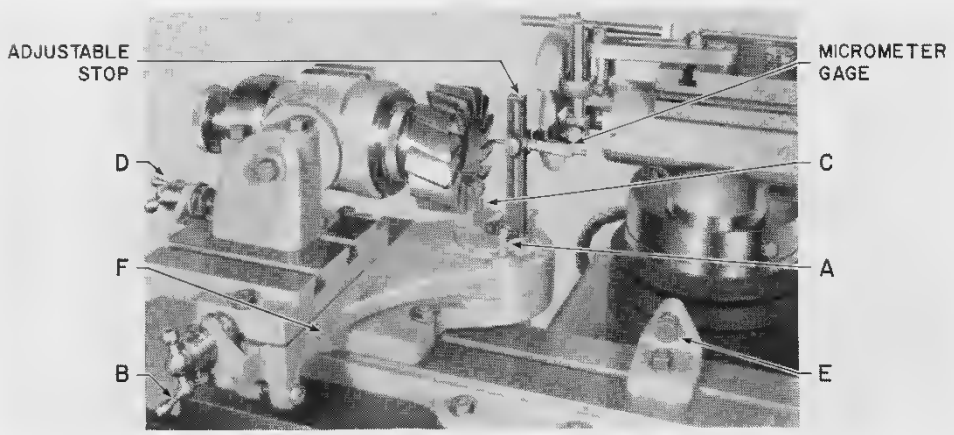


Figure 73A
Set-up for Grinding Radius on 6″ Diameter Shell Milling Cutter.

5. *Mounting Tooth Rest Assembly.* Using the saddle and table controls of the machine, position the attachment so corner of cutter tooth is approximately 1/64″ to 1/32″ from face of wheel (Figure 72A). Mount tooth rest assembly on top of wheelhead, adjust the blade to contact cutter tooth and as close to face of grinding wheel as possible The point or portion of the blade upon which the cutter tooth slides must be directly in front of the grinding wheel and should be the *only* portion in contact with the cutter tooth This is very important if the cutter is to mill a true radius after it is ground. Loosen spindle locking screw on rear of workhead (See Figure 74A for recommended shape of tooth rest blade. It can readily be made from a standard blade)

6. *Grinding Periphery.* Position attachment so grinding wheel is perpendicular to periphery (side) of cutter and tighten locking screw on rear of base plate. Start machine and move saddle handwheel until wheel contacts periphery. Proceed to grind periphery as you would any helical cutter. Take light cuts and make certain all teeth are ground concentric Taper (if present) is eliminated by swiveling table of machine.

7. *Positioning Cutter for Radius* Stop machine, move cutter away from grinding wheel using machine controls, and back up attachment slides far enough to allow micrometer gage to be mounted in tapered hole of attachment. Tapered hole should be thoroughly cleaned before using micrometer gage. Locate against stop pin "A". Set micrometer barrel to proper height (use centering gage) and adjust to desired radius (For a ¼″ radius set micrometer at .250″). Turn crank "B" until periphery of cutter contacts spindle of micrometer (Fig. 73A) Set graduated dial to zero and lock. Turn micrometer gage 90° against other stop pin "C" (Fig. 73A). With micrometer still set at 250″, turn crank "D" until face of cutter contacts micrometer spindle Set graduated dial to zero and lock Remove micrometer gage and replace with tapered plug.

8. *Positioning Table and Saddle* Loosen screw on rear of base plate and position table and saddle of machine so point of cutter tooth swivels on tooth rest blade directly in front of grinding wheel (Figure 72A). Set left-hand table dog so table cannot be further traversed to right.

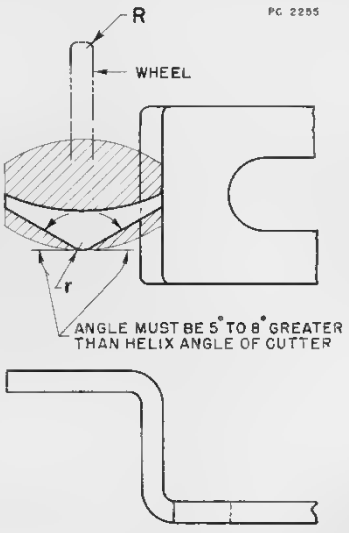


Figure 74A
Tooth Rest Recommended for No. 2 Radius Grinding Attachment Set-ups

9. *Contacting Grinding Wheel.* Position attachment so grinding wheel is perpendicular to periphery of cutter. Tighten screw on rear of base plate. Contact one cutter tooth with tooth rest blade and tighten workhead spindle locking screw. Start machine Hold a thin piece of tissue paper between cutter and grinding wheel Turn saddle handwheel slowly until grinding wheel tears paper. This will indicate that the grinding wheel is within a couple of thousandths of touching the work.

10. *Grinding Face and Radius.* Do not move saddle handwheel except to compensate for wheel wear. Back off crank "D" a few turns and loosen base plate and workhead spindle locking screws. Mount and position adjustable stop bracket on table of machine so knurled screw "E" will contact button "F" in attachment. With cutter tooth on tooth rest blade, swivel attachment through 90° and feed in with crank "D" until wheel starts cutting Grind all teeth at this setting After all teeth are ground rotate cutter 180° from first tooth ground and again move in with crank "D" a small amount. Continue to grind cutter in this manner until zero on dial is reached. At this point compensate for wheel wear in the same manner as discussed in paragraph 9. Back off crank "D" several thousandths. Loosen base plate and workhead spindle locking screws. Move table in with grinding wheel perpendicular to cutter until table dog contacts stop pin. Swivel attachment and again turn crank "D" until wheel starts cutting. Further swivel attachment against adjustable stop and back table out thus grinding face of cutter (See Note 1). Move table back in against stop pin, swivel attachment back approximately 85°, or just before the lines on the attachment coincide. and back table out This will eliminate the nick on the periphery caused by bumping the attachment swivel against the stop. Thus the radius and face are ground in one continuous cut.

Note 1: Wheel will not start cutting on face of cutter until zero reading at crank "D" is reached. Further feeding beyond zero reading is necessary to grind cutter face and will not change the radius.

Note 2: Poor finish on work piece can sometimes be traced to a poor cutter bearing. Cutter bearing can be checked as follows: Coat a small surface plate with red lead. Carefully hold it against face of cutter. Rotate cutter backwards, remove plate and observe red lead on cutter teeth. The cutter bearing should be slightly heavier toward chamfer, tapering off to a very thin bearing toward center of tooth. The setting of the adjustable stop should be changed to suit cutter bearing.

GRINDING A REAMER

When grinding a milling cutter on the CINCINNATI No. 2 Cutter and Tool Grinder, the clearance angle is obtained by merely centering the work with the grinding wheel spindle and then revolving the cutter through the proper number of degrees as read from the dial on the workhead or clearance setting dial. The accuracy of the clearance angle depends upon the accuracy with which these lines have been matched The operator should be very careful in matching up these lines because if they are off a slight amount it may appreciably change the end results Such would be the case if clearance angles were very small. Reamer clearance angles are rather small, especially for the larger sizes, and should be held to close tolerance, therefore, we recommend the vertical adjustment system outlined here, which, incidentally, has been successfully used in our plant for over 75 years.

Two settings are required to obtain the desired "land". First, the vertical adjustment necessary to grind the proper primary clearance angle, and second, the vertical adjustment necessary to grind off the heel of the blade or secondary clearance angle to bring the "land" to the desired width.

By "vertical adjustment" we mean that the wheelhead should be raised or lowered a predetermined amount, this amount is controlled by the type of wheel being used.

If the periphery of a straight flat wheel (Print No. 1Y) is used, raising the centerline of the wheelhead in respect to the centerline of the reamer and using the arc of the grinding wheel, a hollow grind effect for cutting clearance will be produced on the reamer blade This method is outlined in detail on pages 48 and 49 for sharpening an angular milling cutter

If a flaring cup wheel (Print No. 11Y-120) is used, the tooth rest assembly is mounted on the eccentric wheelhead, so that when this unit is lowered it will bring the tooth rest away from the blade and allow the reamer to turn through the proper clearance angle. This method produces a straight grind effect for cutting clearance.

The following general operations are required for sharpening a reamer when using this method.

1. Notice the zero mark on the eccentric wheelhead. Match it with the centering gage placed on the table and set the dial on the elevating crank to zero.
2. To maintain accurate size, a hard, fine grained, resinoid bonded wheel must be used for grinding the cutting clearance.
3 Fasten the tooth rest on the eccentric wheelhead so that the blade is directly in front and on center of the contact area of the wheel, allowing the tooth rest stem to hang loose.

4 Place the centering gage on the table Adjust the tooth rest blade under the gage. The tip of the blade is now central with the center of the grinding wheel and the tail stock centers.

5. Place the reamer between centers.

6 Bring the cutting edge of one tooth against the tooth rest.

7. Lower the wheelhead the amount required for the cutting clearance as given in the table (Pages 85 and 86).

8. Revolve the reamer to again bring the blade against the tooth rest and then proceed to grind the cutting clearance "A", (Figure 77A). Grind the straight as well as the front and rear taper portions at this setting.

9. Lower the wheelhead the amount required for the secondary clearance ("A" + "B" in the table, pages 85 and 86).

10. Again bring the reamer blade against the tooth rest, and finish grinding the reamer by backing off the blade until the "land" of the cutting edge is the width shown in the tables.

If the cutting clearance is to be produced by the cylindrical grinding method, (Figure 78A) then the centers of the work and wheel must be in the same plane with the centering gage. Of course, it is unnecessary to use the tooth rest.

HAND REAMERS

The cutting edge of a hand reamer blade may be considered as divided into three parts. the front taper part which removes most of the metal and allows the reamer to enter the hole freely; the straight part which does the finish cutting and brings the hole to the required finish and diameter, and the rear taper part which prevents the hole from being marred when the reamer is removed (Figure 77A).

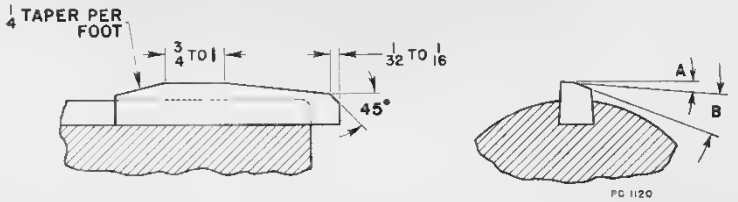


Figure 77A
Profile of a Hand Reamer Blade

The length of the front taper should be as long as possible, depending upon the length of the blade, and it should be ground to a taper of about $\frac{1}{64}''$ per foot, depending upon the amount of metal to be removed.

The straight part of the reamer blade will vary in length depending on the material the reamer will be used on Generally speaking, this straight section will be from $\frac{3}{4}''$ to $1''$ long (Figure 77A) and should be ground to control the size of the reamed hole after machining Characteristic of certain materials causes the reamed hole to change size after machining; this should be compensated for by grinding the reamer slightly larger or smaller or even possibly to the exact size The rear taper part should be about $\frac{1}{4}''$ long and ground to a taper of $\frac{1}{4}''$ per foot

After grinding a hand reamer, a hand stoning operation is sometimes necessary. This operation should be done with extreme care and by a skilled operator. The purpose of hand stoning the reamer blades is to remove any grinding wheel marks, improving the reamed hole finish and give longer life to the reamer, by eliminating unnecessary regrinding. Also, hand stoning is sometimes necessary to remove a small amount to bring the reamer to the exact size required.

Grinding a Hand Reamer for Steel.

FIRST OPERATION—Grinding the cutting clearance

Since the "land" for this type of reamer is only .006" to .008" wide, the cutting clearance can be ground by the cylindrical grinding method.

The cutting clearance produced on the reamer blades, from the cylindrical grinding method, prevents the reamer from "digging in", thus eliminating chatter, giving a better finish to the reamed hole and longer life to the reamer

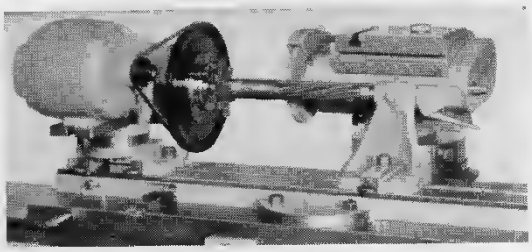


Figure 78A
Cylindrical Grinding the Cutting Clearance on a Hand Reamer

Set up the cylindrical grinding attachment (see pages 64 and 65) and place the reamer between centers, using the universal driving dog on the shank end of the reamer. After the reamer has been placed between centers it should be checked for run-out, this run-out should be held to a minimum to prevent unnecessary grinding, shortening the life of the reamer. Also, it will assure the operator of removing stock from each blade when very little stock is left for finish grinding.

It is very important that the reamer centers be clean, or better still, they may be lapped to insure a good job. Place wheel Print No 1Y (6" diam x ⅛" face x 1¼" hole) on the grinding wheel spindle, use the centering gage and set the zero line on wheelhead in the same horizontal plane as tailstock centers. Be sure that the rotation is such that the heel of the blade strikes the grinding wheel first; otherwise there will be no cutting clearance (Figure 78A). Use the front hand table feed for moving the reamer past the wheel.

Three settings are required:

1. Cylindrical grind straight the full length of the blade. (Use micrometer to test for parallelism and size).
2. Swivel the table and cylindrical grind the back taper (Figure 77A).
3. Swivel the table in the opposite direction and cylindrical grind the front taper (Figure 77A).

SECOND OPERATION—Grinding the Secondary Clearance (Fig. 79A)

Two separate settings are required, but each reamer blade or tooth must be ground separately Use the figures in the second column under Table 1 (pages 85 and 86) for this operation. For the standard stock removal of .002", the blade should be backed off until the "land" is .006" to .008" wide. If more than 002" stock is to be removed, the "land" can be somewhat wider: and if the hole is very large, it may be advisable to use two hand reamers—a roughing and finishing

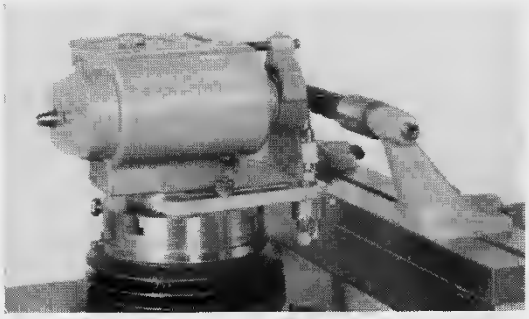


Figure 79A
Setup for Grinding the Secondary Clearance on a Hand Reamer

The settings are as follows

1. Grind the secondary clearance on the front taper part.
2. Swivel the table to zero and grind the secondary clearance on the straight part. (See tables).

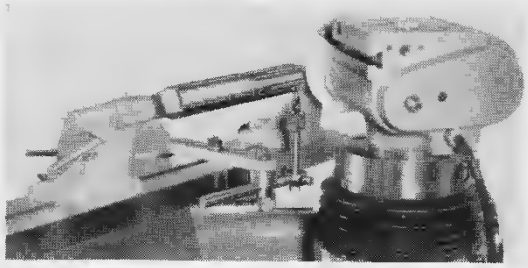


Figure 79B
Beveling the Corners of the Blades on a Hand Reamer

Since it is necessary to bevel the corners, attach the tooth rest to the table, swing the table to an angle of 45°, and set the dogs on the slide to limit the stroke Disengage the table feed crank and use the rear knob control, holding the reamer against the blade with the other hand (Figure 79B).

Grinding a Hand Reamer for Cast Iron or Bronze. When grinding a hand reamer for cast iron or bronze, the cutting clearance cannot be ground with the cylindrical grinding attachment, because the clearance required is too great, and the reamer will not cut as well as when each blade is ground separately.

After setting up the machine with the cup wheel, two operations are required

FIRST OPERATION—Grinding the cutting clearance

1. Grind straight the full length of the reamer (See tables on pages 85 and 86). Test for size and parallelism with micrometer.
2. Swivel the table and grind the back taper part (Figure 77A).
3. Swivel the table in the opposite direction and grind the front taper part to a taper of about $\frac{1}{64}$" per foot

SECOND OPERATION—Grinding the Secondary Clearance or Backing Off

For the standard stock removal of 002", the blade of a hand reamer for cast iron or bronze should be backed off until the "land" is .020" to 025" wide

1. Grind the secondary clearance on the front taper part
2. Set the table to zero and grind the secondary clearance on the straight part (See tables)

CHUCKING OR MACHINE REAMERS

Grinding a Chucking Reamer for Steel. Two reamers, a roughing and a finishing reamer, are usually employed to finish the hole in a steel part if a good finish is required, as for a bearing If the finish requirements are not so exact, as a hole which has a bronze bushing pressed into it, then only one reamer is required These reamers may be inserted blade, solid or adjustable type reamers. If the adjustable type reamers are used and do not cut to size, we recommend that they be adjusted oversize and reground to the desired size, unless a very small adjustment is all that is necessary For small diameter holes, the solid type is generally used

Roughing Reamer The profile of a blade in a roughing reamer for steel is shown in Figure 80A. The straight part should be ground about .002" less than the required diameter of the hole Since the beveled corner, on the end of the reamer, does most of the work, it should be given the proper clearance angle to avoid any drag on the heel of the blade.

The figures given in the following settings are for a roughing reamer which will remove up to $\frac{1}{32}$" stock. It should be noted that a new solid reamer is oversize, which makes it necessary to grind the outside diameter of the teeth before using.

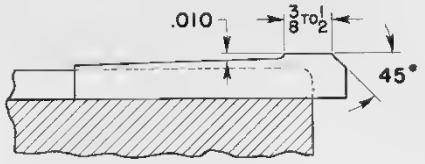


Figure 80A
Profile of a Roughing Reamer Blade for Steel

FIRST OPERATION—Grinding the Secondary Clearance or Backing Off

This operation differs slightly from the set-up for grinding reamers given on pages 78 and 79, because the periphery of a saucer wheel (Print No 12Y-155) is used throughout, to avoid changing when setting up for grinding the corners

1. Place the centering gage on the table and adjust the wheelhead column to the zero line
2. Fasten wheel Print No 12Y-155 to the grinding wheel spindle
3. Raise the wheelhead 650" to .700" for the secondary clearance

4 Clamp the tooth rest in position *on the table*, allowing the tooth rest stem to hang loose. Place the centering gage on the table in front of the wheel, and bring the tooth rest blade up under the gage and clamp

5. Place the reamer between centers, and bring the cutting edge of one tooth against the blade

6. Proceed to grind the blades their full length, allowing a land of about .015".

SECOND OPERATION—Grinding the Cutting Clearance

Cylindrical grind the cutting clearance to the desired diameter, similar to grinding the cutting clearance on a hand reamer for steel. The rotation of the wheel and reamer must be such that the heel of the reamer blade strikes the wheel first, in order to produce cutting clearance

THIRD OPERATION—Grinding the Blade Relief

Cylindrical grind the back end of the blades about .020" smaller than the hole diameter, allowing about ½" length of cutting blade (Figure 80A).

FOURTH OPERATION—Grinding the Corners

Swivel the table to 45° and grind the corners, using the same wheelhead setting as for grinding the secondary clearance (Figure 79B).

Finishing Reamer. The profile of a blade for a finish machine reamer for steel is shown in Figure 81A. These finishing reamers are different from the roughing reamer in that the cutting is done by the front taper part of the blade, and by the corner. Two to six thousandths should be removed from the diameter of the hole by the finishing reamer. Two operations, using wheel Print No. 1Y, are required when grinding.

FIRST OPERATION—Grinding the Cutting Clearance

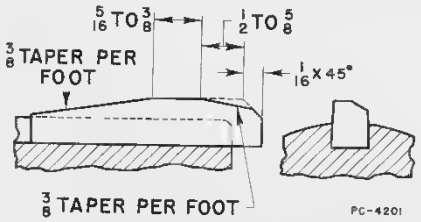


Figure 81A
Profile of a Finishing Reamer Blade for Steel

1. Cylindrical grind straight the cutting clearance the full length of the blade Again we call attention to the fact that the heel of the reamer blade must strike the wheel before the cutting edge, in order to produce a clearance

2. Swivel the table and cylindrical grind the back taper part to a taper of ⅜" per foot.

3. Swivel the table and cylindrical grind the front taper part to a taper of ⅜" per foot, allowing about 5/16" to ⅜" length for the straight part

SECOND OPERATION—Grinding the Secondary Clearance or Backing Off

Back off the blade until the land is .006" to .008" wide

1. Back off the front taper part

2. Swivel the table straight and back off the straight part. (See tables).

Grinding a Chucking Reamer for Cast Iron. The profile of a chucking or machine reamer for cast iron is the same as a finish machine reamer for steel, shown in Figure 81A. Dimensions given in the illustration are for a reamer which is to remove .005″ to .015″ from the hole, depending upon the diameter. After setting up the machine as described on pages 76 and 77, two operations are required, using the cup wheel, (Print No 11Y-120)

FIRST OPERATION—Grinding the Cutting Clearance

1. Grind straight the full length of the reamer blades
2. Swivel the table and grind the back taper part
3. Swivel the table in the opposite direction and grind the front taper part

SECOND OPERATION—Grinding the Secondary Clearance or Backing Off

Back off the blade until the land is 015″ to .020″ wide

1. Back off the front taper part.
2. Swivel the table straight and grind the straight part.

Grinding a Chucking Reamer for Bronze. The profile of a machine reamer for bronze is shown in Figure 82A. Note that the corners of the teeth do most of the cutting, similar to a roughing reamer for steel. The figures given in the illustration are for a reamer which is to remove 005″ to .015″ from the hole, depending upon the diameter Three operations are required for grinding.

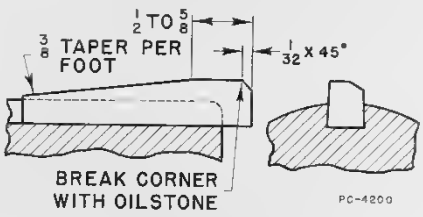


Figure 82A
Profile of a Machine Reamer Blade for Bronze

FIRST OPERATION—Grinding the Cutting Clearance

1. Grind straight the full length of the blade
2. Swivel the table and grind the rear taper part.

SECOND OPERATION—Grinding the Secondary Clearance or Backing Off

Back off the blade until the land is .015″ to .020″ wide.

1. Swivel the table straight and back off the straight part.

THIRD OPERATION—Bevel the corners of the blades

Grind the corners of the blades, using the same method as outlined for grinding the corners of the blades of a roughing reamer for steel.

After the above grinding operations are complete, oilstone the corner of the blade to a slight radius as indicated in Figure 82A

TAPER REAMERS

Grinding a Straight Fluted Taper Reamer. A little more care must be used when grinding a taper reamer than when grinding a single diameter reamer, because there are two considerations instead of one.

Figure 82B—A Taper Reamer

the taper and the diameter After reamer has been mounted between centers, indicate for run-out. it should be no more than 0002" to 0005" Use a collet for gaging Take a trial cut with the finished reamer and test the hole with a standard plug before the reamer is used

When setting up, proceed as follows·

1. Place the centering gage on the table and adjust the column to the zero mark
2. Fasten a fine grain disc wheel, Print No. 1Y, (6" diam x 1/8" face x 1 1/4" hole), to the left hand end of the spindle.
3. Set the dial on the elevating crank to zero, and raise the wheelhead from .300" to 400" (About .300" for hard material and .400" for soft material).
4. Mount the tooth rest on the eccentric wheelhead with the blade directly in front of the arc of the wheel. Place the centering gage on the table and adjust the tooth rest blade under the gage (Figure 83A)
5. Adjust the table to the correct taper with the aid of the fine taper device or Tange-bar taper setting device
6. Place the reamer between centers, move the saddle towards the wheel and bring one of the reamer teeth against the tooth rest blade

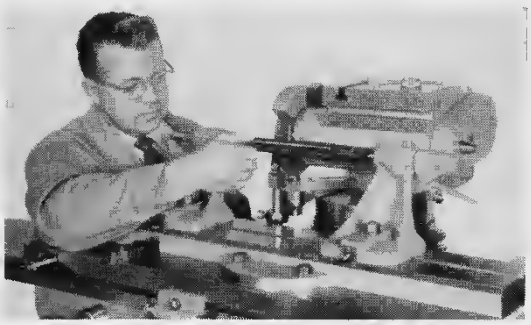


Figure 83A—Grinding a Taper Reamer

7. Take a test cut for the correct taper, and then proceed to grind. Check the previous grind on the taper reamer, if within tolerance, red-lead one blade and adjust table by using the fine taper adjustment to match previous grind. This will eliminate excessive grinding, insuring longer reamer life

Grind one tooth .0002" higher than the balance of the teeth, a free cutting action with freedom from chatter will be obtained Of course, this suggestion applies only to finishing reamers This high tooth also prevents the reamer from locking in reamed hole

If the land of the cutting clearance is more than 1/32" wide, the teeth should be backed off before the cutting clearance is ground

The cutting edges of a straight tooth taper reamer must be straight to produce good results. Usually, oil-stoning the faces of the teeth is sufficient However, if they are too irregular to be straightened up in this manner, they may be ground with the dish wheel. Support the reamer between the workhead and tailstock centers, and swivel the workhead housing enough to bring the bottom of the flute parallel with the top of the table

Grinding a Spiral Fluted Tapered Reamer. The set-up for this operation requires more attention to detail than other types of reamers. For example, center holes must be lapped and clean. Do not have too much tension on the adjustable tailstock center, or the reamer will be difficult to turn, resulting in uneven cutting edges and wheel gouging.

Instructions given are rather brief, for it is assumed that the operator who grinds a tapered reamer has had previous experience in grinding other types of cutters.

1. Mount the reamer between right and left-hand tailstocks, omitting the clearance setting dial.
2. Mount wheel Print No. 1Y (6″ diam. x ⅛″ face x 1¼″ hole), to the left-hand end of the spindle. If a narrower wheel is available, it can be used to advantage. Set the eccentric wheel head to zero angular setting.
3. True the grinding wheel with a diamond. The grinding wheel should have a radius on each side. This can be done with a hand dressing stick.
4. With the centering gage on the table, adjust the wheelhead vertically to gage height.
5. Set the dial on the elevating crank to zero, and raise the wheelhead .300″ to .400″ (approx. .300″ for hard materials; .400″ for soft materials).
6. Mount the tooth rest assembly to the wheelhead, using the solid post type. To avoid interference with teeth other than the one being ground, it may be necessary to alter the tooth rest blade.
7. With centering gage on table, carefully adjust the tooth rest blade to gage height, directly in front and on center of the contact area of the grinding wheel. Unless this is done properly, the reamer will cut a bell shaped hole. Use a blade similar to Figure 30B, except having a smaller radius.
8. Adjust the swivel table to the taper desired. For methods of adjusting table see pages 23 to 25.
9. Apply a thin coat of red-lead or "Prussian" blue to the reamer blades. Take a light grinding cut on one blade and visual check to see if correct calculations were made, if so, proceed to grind remaining blades.
10. Check the accuracy of the set-up by actually reaming a hole, and test it with a master plug gage. If the hole is bell shaped, readjust the tooth rest and regrind. Also check centers both in a horizontal and vertical plain.

REAMER CLEARANCE TABLES
(When Using Cup Wheels Only)

SIZE OF REAMER	TABLE 1 Hand Reamer for Steel. Land of Cutting Clearance .006 Wide		TABLE 2 Hand Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide		TABLE 3 Chucking Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide	
	Vertical Adjustment for Cutting *Clearance Angle "A" Figure 77A	Vertical Adjustment for Second Clearance Angle "A" + "B" Figure 77A	Vertical Adjustment for Cutting Clearance Angle "A" Figure 77A	Vertical Adjustment for Second Clearance Angle "A" + "B" Figure 77A	Vertical Adjustment for Cutting Clearance Angle "A" Figure 77A	Vertical Adjustment for Second Clearance. Angle "A" + "B" Figure 77A
1/2"	.012"	052"	032"	.072"	040"	080"
9/16	.012	057	.032	072	040	080
5/8	.012	062	032	072	.040	090
11/16	.012	067	035	095	.040	.100
3/4	012	072	.035	095	.040	.100
13/16	.012	077	.037	095	045	125
7/8	.012	082	.040	.120	.045	125
15/16	012	087	040	.120	045	.125
1	.012	092	.040	.120	.045	125
1 1/16	012	097	.040	.120	.045	125
1 1/8	012	102	040	.120	.045	.125
1 3/16	012	106	042	122	045	.125
1 1/4	.012	112	.045	145	050	.160
1 5/16	012	.118	.045	145	.050	.160
1 3/8	012	.122	045	.145	.050	.160
1 7/16	.012	.127	.045	145	055	175
1 1/2	.012	.132	.048	168	055	.175
1 9/16	012	137	.050	170	.055	.175
1 5/8	.012	142	.050	.170	.060	.200
1 11/16	.012	147	.050	170	.060	.200
1 3/4	.012	.152	052	192	060	.200
1 13/16	012	157	.052	192	.060	.200
1 7/8	012	162	.056	196	.060	.200
1 15/16	.012	167	.056	196	.064	.200
2	.012	172	056	216	064	224
2 1/16	012	172	056	216	.064	224
2 1/8	012	172	.059	219	.064	.224
2 3/16	012	172	.059	219	.064	224
2 1/4	012	.172	.063	.223	064	.224
2 5/16	012	172	.063	223	.064	.224
2 3/8	012	172	063	223	068	.228
2 7/16	012	172	063	223	068	.228
2 1/2	.012	172	.065	225	.072	.232
2 9/16	.012	172	.065	225	.072	232
2 5/8	012	172	.065	225	.075	235
2 11/16	012	172	065	225	.075	235

*See note, following page

REAMER CLEARANCE TABLES
(When Using Cup Wheels Only)

SIZE OF REAMER	TABLE 1 Hand Reamer for Steel. Land of Cutting Clearance .006 Wide		TABLE 2 Hand Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide		TABLE 3 Chucking Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide	
	Vertical Adjustment for Cutting *Clearance. Angle "A" Figure 77A	Vertical Adjustment for Second Clearance Angle "A" + "B" Figure 77A	Vertical Adjustment for Cutting Clearance Angle "A" Figure 77A	Vertical Adjustment for Second Clearance Angle "A" + "B" Figure 77A	Vertical Adjustment for Cutting Clearance. Angle "A" Figure 77A	Vertical Adjustment for Second Clearance. Angle "A" + "B" Figure 77A
2 3/4"	012"	.172"	065"	.225"	.077"	237"
2 13/16	012	172	065	225	.077	237
2 7/8	.012	.172	.070	230	.080	240
2 15/16	.012	.172	070	230	.080	.240
3	.012	.172	.072	232	.080	240
3 1/16	.012	.172	.072	232	.080	240
3 1/8	.012	.172	075	235	.083	240
3 3/16	012	.172	075	235	.083	243
3 1/4	.012	.172	078	238	.083	.243
3 5/16	.012	.172	078	238	.087	243
3 3/8	.012	.172	081	241	.087	247
3 7/16	.012	.172	.081	241	.090	247
3 1/2	.012	.172	084	244	.090	250
3 9/16	.012	.172	.084	244	.090	250
3 5/8	.012	172	.087	247	.093	253
3 11/16	.012	.172	087	247	.093	253
3 3/4	.012	.172	090	250	.097	257
3 13/16	.012	.172	.090	250	.097	.257
3 7/8	.012	.172	093	253	.100	.260
3 15/16	012	172	.093	253	.100	.260
4	.012	.172	096	256	.104	.264
4 1/16	012	172	096	256	.104	.264
4 1/8	012	172	096	256	.104	.264
4 3/16	.012	.172	.096	.256	.106	.266
4 1/4	.012	172	.096	256	.106	.266
4 5/16	.012	.172	.096	256	.106	.266
4 3/8	012	.172	.096	256	108	.268
4 7/16	.012	.172	.096	256	.108	268
4 1/2	012	.172	.100	260	.108	.268
4 9/16	.012	.172	100	260	.108	.268
4 5/8	012	.172	100	260	110	.270
4 11/16	012	172	.100	260	110	270
4 3/4	012	.172	104	264	114	.274
4 13/16	012	172	104	264	.114	.274
4 7/8	.012	.172	106	266	.116	.276
4 15/16	012	.172	106	.266	.116	.276
5	012	172	110	270	118	.278
5 3/8	.012	172	.118	278		

*Note: If a cylindrical grinding attachment is available, use it for grinding the cutting clearance (See page 78) Then the first column in Table 1 should be disregarded.

RECOMMENDATIONS FOR GRINDING CARBIDE MILLING CUTTERS

If at all possible, a separate department should be responsible for the exclusive grinding of carbide milling cutters. When several cutter grinders are available, considerable set-up time can be saved by leaving one machine set up for circle grinding, another for grinding the tooth face, and one or two others for grinding the clearance angles.

If a separate department is not warranted, only experienced carbide grinder men should handle the work. Quite aside from all the other do's and don'ts of carbide grinding, the operator should be especially careful to avoid the overheating of the sintered carbide. Furthermore, he should make sure that defects and wear marks left on the tool from previous cutting operations have been removed. Only in this manner can consistently good results be obtained on the milling machine.

It is also important that proper care be taken of the diamond wheel, which are used when grinding tungsten carbide cutters. These grinding wheels should be mounted permanently on collet assemblies and indicated for run-out before using. When not in use they should be stored in a safe place where they can not be chipped or cracked It is also important to save the worn out or broken grinding wheels, as well as the diamond swarf, which can be returned to the manufacture for credit

Storing and Handling of Cutters

Each cutter, when not in use, should be stored in a sturdy wooden box. More cutters are broken through negligence than through wear and overload during the cutting operation. For this reason, the cutter should remain in its box during transportation between toolroom and milling machine.

Cutters may be given added protection by coating the carbide tips and adjacent surfaces with a plastic In this manner, a tough, skin-tight protective film is formed over the tooth surfaces which can be readily peeled off the next time the cutter is used

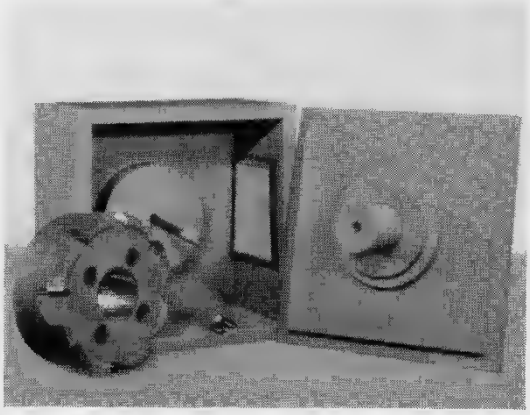


Figure 87A
Suggested Method for Storing Carbide Mills

Marking of Cutters

Due to the expense involved in maintaining sintered-carbide cutters, a careful study should be made as to correct angles which when ground on the cutter will perform most efficiently for the particular job it is used on An appropriate record card should be made of this information and fastened in the box, in which the cutter is stored (Figure 87A). The following information should appear on the example card shown below.

a Axial rake angle
b Radial rake angle
c Corner angle
d Resultant rake angle
e. Clearance angle
f Type of carbide
g. Date of each grind
h Serial Number

CARBIDE CUTTER CARD

Serial No.		Tool No.	
Cutter Type		Teeth	Make
Diameter	Hand		Bore
Corner Angle	Axial Rake		Radial Rake
Body Thickness	Body Mat'l		Tip Size

Grade of Carbide										
Chamfer Land or Face Edge Face Angle										
Face Relief										
Peripheral Clearance										
Tips Replaced										
Tips Reset										
Grinding Time (Hrs.)										
Date Ground										
Grind	1	2	3	4	5	6	7	8	9	10

Figure 88A
Cutter Grinding Record

This information will serve both to identify the cutter and to instruct the grinder operator in the right angle setting.

Equipment Required

1. CINCINNATI No. 2 Cutter and Tool Grinder attachments

2. Spotlight mounted on grinder to provide concentrated illumination where needed

3. Wheels The diamond wheels recommended below are of the standard resinoid bond. The shape recommended for the cup wheel is one having a diamond section $\frac{1}{8}''$ wide by $\frac{1}{8}''$ thick mounted on the rim of the wheel. The diamond grinding wheels should be mounted permanently on their collets: that is, once the wheel has been trued, it should not be removed from the collet for the remainder of its life. Cup wheels should be indicated for face runout and straight wheels for peripheral runout. This runout should be reduced to .00025" or less by scraping the backs of the hubs of the cup wheels or by radially shifting the straight wheels on their collets. The bore in the straight wheel has been made .005" oversize for this purpose. Periodic checking of these wheels will greatly increase their life

   a. Flaring Cup or Flat Wheels for General Grinding and Finishing; 150 to 180 grit, resinoid bond, 100 concentration

   b. Flaring Cup or Saucer Wheels for Grinding the Tooth Face, 150 to 180 grit, resinoid bond, 100 concentration.

   Note: If desired, this wheel can be used for general purpose carbide grinding. When used for grinding the tooth face, it is usually placed on a 2" Spindle Extension.

   c. Roughing Wheel for Circle Grinding; A silicon-carbide wheel should be provided for circle grinding. We recommend a 60 grit 6" diameter, $\frac{1}{2}''$ wide, $1\frac{1}{4}''$ hole grinding wheel

   Note: It has been found that the expensive diamond wheel is not necessary for circle grinding operations

4. A double end diamond hand hone, 400 grit on one end and 500 grit on the other, vitrified bond, 100 concentration, $\frac{1}{32}''$ diamond depth This diamond hone is only used when a hand operation is desirous.

5. A diamond wheel dressing stick Pumice stone for dressing finishing wheels.

6. A magnifying glass, 10 to 20 power

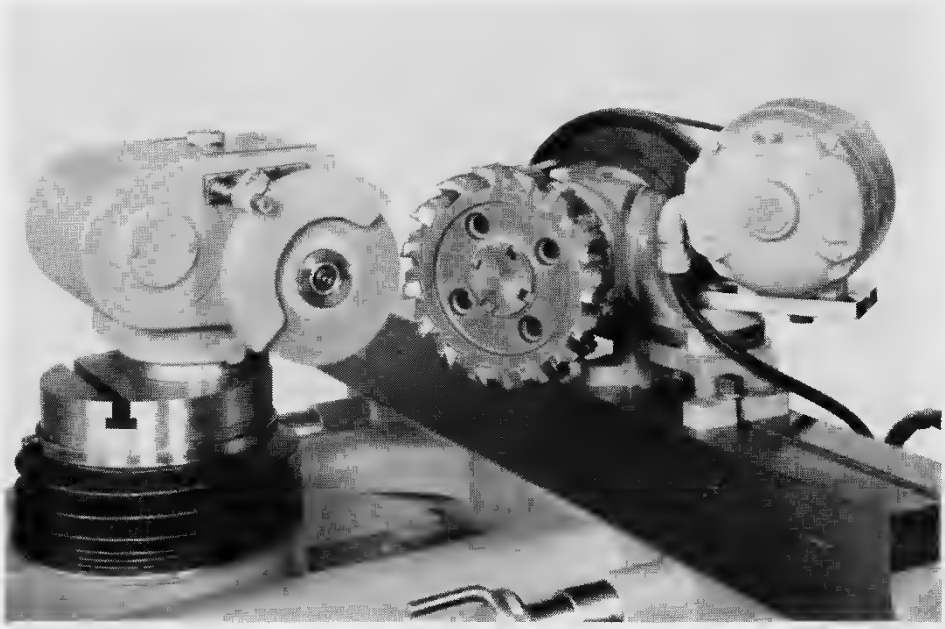


Figure 90A
Circle Grinding Set-up

General Instructions

1 Sintered carbide tipped milling cutters are generally sharpened by first using silicon-carbide grinding wheels for the roughing operations —cylindrical grinding, removing the excess carbide behind the cutting edge; cutter body interference. Diamond grinding wheels are generally used for finishing operations on the cutting edge. On roughing operations care should be exercised when using silicon-carbide grinding wheels. Excessive grinding pressure will glaze the grinding wheel, resulting in high temperatures in the cutter body, causing heat cracks in the carbide teeth. When circle grinding (Figure 90A) excessive pressure may be built up by too fast a feed rate resulting in a bumping action from tooth to tooth causing the carbide to flake or chip on the cutting edges. High temperatures resulting from excessive grinding pressures, when using diamond grinding wheels, will cause the diamonds to be loosened from the bonding material, reducing the grinding wheel life.

2. In sharpening sintered carbide tipped cutters, particular care should be taken to avoid the formation of heat cracks or "checks". This will occur if the feed rate is too fast, the amount of stock removed per pass is too great, or the grinding wheel is permitted to load or glaze. The amount of stock removed per pass should be from .00015" to a maximum of .0004", depending on the grit of the grinding wheel and the type of operation. More stock can be removed per pass when *rough grinding* and correspondingly less stock should be removed when *finish grinding*. The cutter tip should be fed past the wheel by hand at a rate

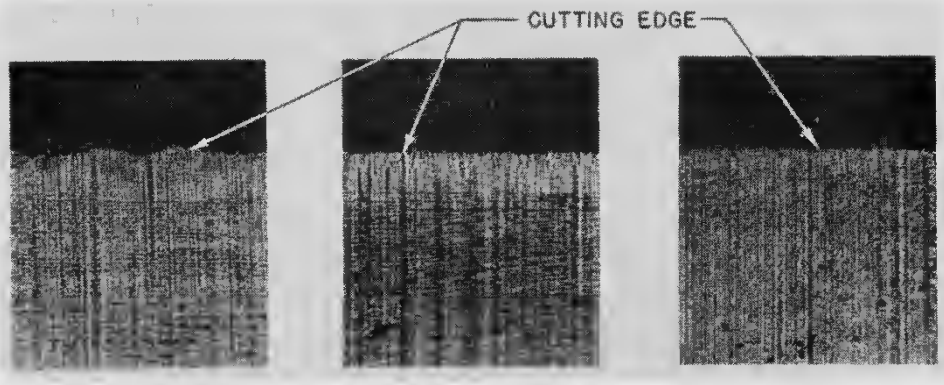


Figure 91A

Photomicrographs showing the condition of the cutting edge of sintered carbide tips ground with different kinds of grinding wheels. Magnified 100 diameters.

of about 50″ per minute in roughing and about 10″ to 20″ per minute in finishing.

3. The selection of a diamond grinding wheel is governed by the type of operation, the speed available in the machine, and the degree of finish desired. With a wheel of 80 to 150 grit, it is comparatively easy to rough grind for stock removal. An excellent cutting edge can be obtained with 180 to 240 grit wheels (Figure 91A). The surface speed of the resinoid and vitrified bonded grinding wheel is generally 5000 to 6000 surface ft. per minute, metal bonded wheels as low as 3000 surface ft. per minute.

4. *Check diamond wheels for true running.* True running is essential with diamond wheels because they are expensive, and the relatively thin diamond coating would quickly be worn away and wasted by ordinary truing. To obtain true running, diamond wheels are mounted on tapered bushings They should be mounted on the spindle of the cutter grinder with special care and checked for true running by means of a dial indicator.

5. Do not grind into the body of the cutter with a diamond wheel, as this will cause the wheel to load up rapidly The carbide tips should project .040″ to .060″ beyond the cutter body after the original brazing operation. Grinding wheel clearance should be provided in the original body design. Ample wheel clearance also should be provided for the face of the tooth. When the carbide has been ground down to such an extent that the cutter body interferes with the free action of the grinding wheel, the carbide tips should be set out again or replaced.

6 Use a magnifying glass to examine the carbide, both before grinding and at intervals during the grinding operation. Cracks and flaws in the carbide, and crater and abrasion marks produced in cutting should be ground away in the roughing operation.

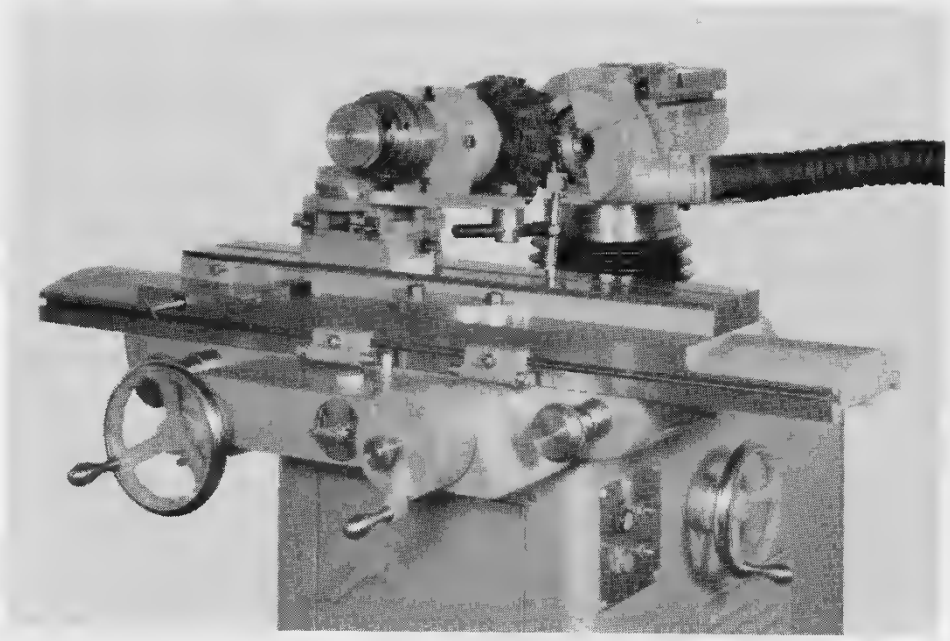


Figure 92A
Grinding the Face of the Cutter

7. *Sharpen cutters WET.* Wet grinding is preferred when sharpening with diamond wheels, CIMCOOL®, a product of the Cincinnati Milling Products Division, is recommended as a cutting fluid Strong alkaline solutions should be avoided, since they are injurious to Bakelite bonding. The wick-and-oil cup method of moistening the face of the wheel is still largely used. A more efficient method is offered by some commerical manufacturers of mist attachments, similar to the one shown in Figure 92A

8. During the grinding operation, hold the cutter in the same manner as it will be held on the milling machine. i e. face mills should be bolted to the flange of the face mill arbor, shell end mills should remain on their arbors during the grinding operation, etc.

9. After the complete grinding operation, the cutter teeth should be examined carefully with a 10-20 power magnifying glass if any defects on the cutting edges show up at this time, the cutter must be resharpened The surface finish on a carefully ground tooth should be below 5 micro-inches

10. The cutter teeth should be checked for run-out. In addition, the clearance and body interference should be checked carefully. These latter steps are especially important for small diameter cutters and radius cutters.

11. *Hone the face and the land, if a hand operation is desirous,* with a 400 or 500 grit diamond hone.

Specific Recommendations for Grinding a Carbide-Tipped Face Mill

Now that the general recommendations have been covered, it will be applied to a specific job; namely, the grinding of a carbide-tipped face mill. The following represents a chronological order of the required procedures. The recommendations are based on the use of the best grinding wheels and equipment now commercially available.

CASE 1 Grinding a Face Mill after new tips have been brazed in place:

a Circle grind the periphery, the face, and finally, the chamfer Use a 60 grit silicon-carbide straight wheel, 6″ diameter and ½″ wide

b Grind the face of the carbide tip Set the tooth rest behind the projection of the carbide tooth after first filing all excess braze off the carbide. After the tooth has been adjusted for its proper rake, this rake is maintained by feeding the tooth rest so as to rotate the cutter. In general, one tooth can be ground completely before passing on to the next tooth. Care must be exercised to prevent overheating of the carbide during the grinding operation.

c. Grind the primary peripheral land. If this land should be too long, grind a secondary land.

d. Grind the clearance on the cutter face. If the face angle is less than 1°, grind a secondary face relief. The flat portion of the face cutting edge should exceed the feed per revolution by approximately 25 per cent.

e. Grind the clearance lands on the chamfer, (See page 114).

f. Check the run-out on the periphery, the corner, and the face, using a 1/10,000″ indicator. And at the same time, make certain that no part of the cutter body projects beyond the cutting edge. It is desirable that run-out be kept to .0005″ for cutters up to 6″ and .001″ for cutters up to 12″ in diameter. For this checking operation the cutter should be removed from the attachment and placed on a stud either on the machine table or surface table

g If the cutter is to be used for the milling of steel, bevel the cutting edges .002″ x 45° by hand with a diamond hone

h. Inspect the cutter teeth with a magnifying glass, making certain that no defects are present on the cutting edges. Store the cutter in its box.

CASE 2: Regrinding a face mill that has been dulled in cutting operations

a Inspect the carbide and estimate the magnitude of wear on the cutting edge to determine how much carbide will have to be ground off the face and peripheral lands of each tooth.

b. Grind the face of each tooth as before, using a magnifying glass to guide the depth of the grind.

c. Grind the clearance lands of each tooth as before, making certain that all defects in the carbide have been removed.

Recommended Primary Clearance Angles
(Based Upon Recent Practice)

TYPE MILL	TRUE PRIMARY CLEARANCE ANGLES (Degrees)								
	Periphery			Chamfer			Face		
	Steel	C. I.	Al	Steel	C. I.	Al	Steel	C. I.	Al
Face or Side	4–5	7	10	4–5	7	10	3–4	5	10
Slotting	5–6	7	10	5–6	7	10	3	5	10
Saw	5–6	7	10	5–6	7	10	3	5	10

The maximum usable length of the primary clearance land on the periphery and the chamfer is a function of the cutter diameter, clearance angle, and feed per tooth. A 1/32″ land is suitable for general work with cutters 3″ to 8″ in diameter.

The secondary clearance angle on the periphery and the chamfer may be 3° to 5° more than the primary clearance angle.

Condition	Face Angle	Fig. No.
For roughing operations	1½° to 2°	95A
For good finish	Flat to exceed feed per revolution by approximately 25%	95B
For highest grade finish	¾° x 1/16" Additional Chamfer with flat to exceed feed per revolution by approximately 25%	95C

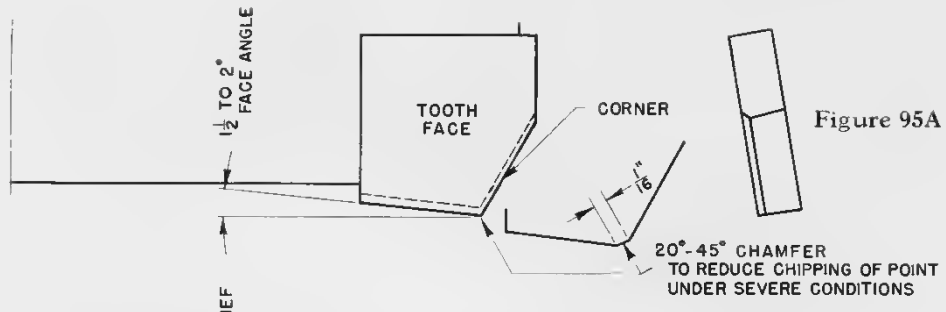


Figure 95A

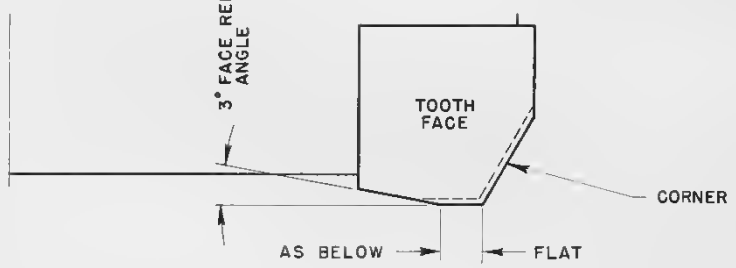


Figure 95B

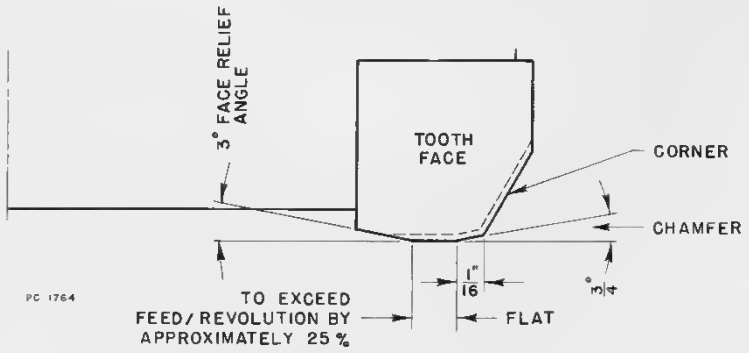


Figure 95C

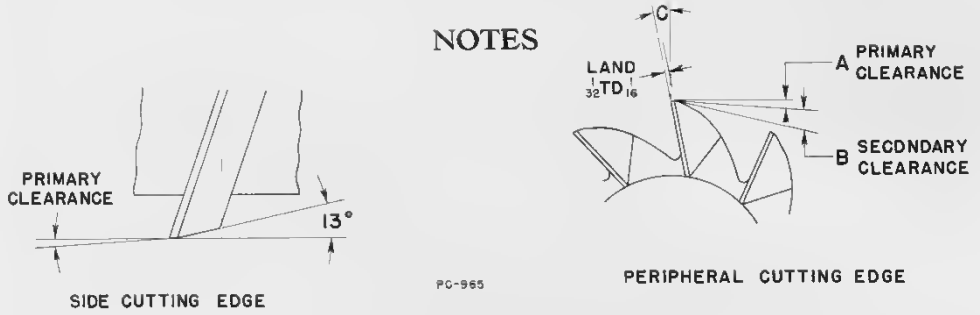


Figure 96A

Write it Down. When considerable experimenting with the variable factors in cutter sharpening has produced higher production and longer cutter life, we recommend that the clearance angles and "land" be entered in a table such as the one shown here. Then the superior results, once obtained, can again be duplicated without loss of time.

Cutter No.	A	B	C	D	E	Part Number and Material of Work

CLEARANCE ANGLE SETTINGS

In grinding the clearance angle with the side of a cup wheel or the periphery of a disc type grinding wheel, the desired clearance is generally obtained by setting the center of rotation of the grinding wheel below or above the center line of the cutter by a predetermined amount "A", while the cutting edge, supported by a tooth rest, is maintained in a fixed relation to the grinding wheel. This will cause the grinding wheel to produce a land on the back of the tooth, inclined with respect to the tangent, to the cutter periphery by a small angle, which is the clearance angle

The values of "A", which increases with the diameter of the grinding wheel, apply to plain milling cutters with either straight or helical teeth, and slotting cutters mounted on arbors and supported between centers; to grinding the sides of side mills or the face of shell end mills mounted in the universal workhead

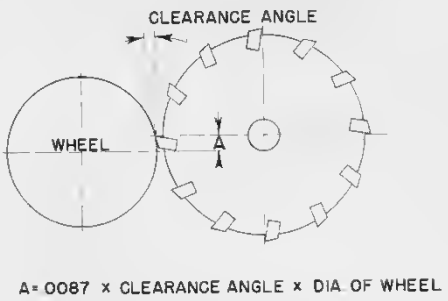


Figure 97A
Left Hand Face Mill

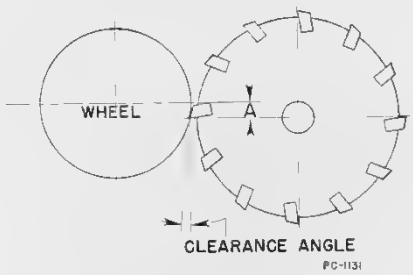


Figure 97B
Right Hand Face Mill

Wheel Diam.	CLEARANCE ANGLE									
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	DISTANCE A IN INCHES									
3	.026	.052	.078	.104	130	156	.182	.208	.235	.261
4	.034	069	.104	.139	.174	.208	243	.278	.313	.348
5	043	.087	130	174	.218	261	305	.348	392	435
6	.052	104	.157	209	262	.313	365	418	.470	.522
7	.061	.122	182	.244	304	.365	426	.487	548	.609
8	069	139	.209	278	.347	418	487	.557	628	.696
9	.078	.157	235	.313	391	470	548	626	.705	793
10	.087	.174	.261	.348	434	.522	.609	.696	.783	.870

SALVAGING CUTTERS

Plain Milling Cutters. Many high speed steel milling cutters, especially the more common types such as helical mills and slotting cutters, can readily be salvaged (also known as "recutting") when the teeth have been ground down too far to accommodate chips (Figure 98A)

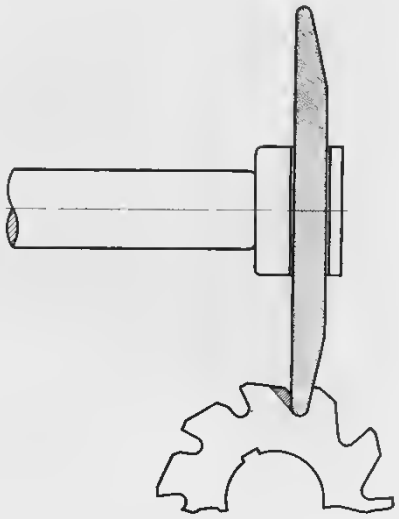


Figure 98A
Cutters May be Renewed or Salvaged by Grinding Additional Chip Clearance

Many elements of the set-up for this type of operation are common to both salvaging and sharpening and therefore, detailed instructions are not given. However, there are a few very important differences, all of which are discussed here. Incidentally, the three principal operations create a large amount of grit, and for this reason it is advisable to do them on an old machine.

When salvaging helical mills, during the first operation the tooth rest should be mounted on a *stationary* unit (not the wheelhead). Considerable vertical adjustment of the wheelhead (as required for depth of gullet) obviously alters the tooth rest setting. The usual mounting surface is on top of the saddle. Parts for this mounting can readily be made in any shop.

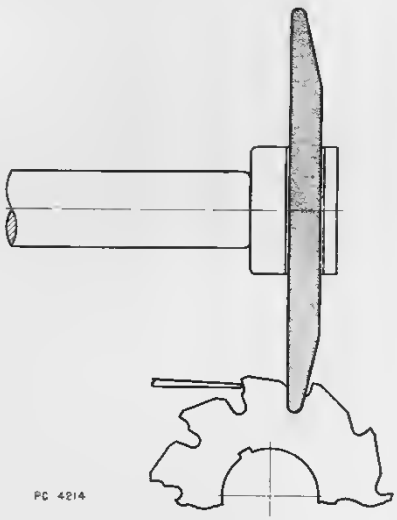


Figure 98B
First Operation in Cutter Salvaging

1 The first operation consists of rough grinding the gullet to depth, (Figure 98B) Offset the cutter a sufficient amount to follow the original rake angle. Grinding wheels known as hob wheels, 6″ x ½″ x 1¼″, with 12° side angle, may be purchased for this operation. If desired, a straight sided wheel of these dimensions may be dressed to the required angle Grind one gullet at a time, feeding to depth in increments of .005″

With the grinding wheel running at the slowest speed (belt on inner pair of step pulleys Figure 20A) there will be less danger of "burning" the cutter. Note that the *angular* side of the wheel grinds the face of the tooth on *helical* cutters, thereby retaining the original rake angle. The straight side of the wheel may be used for grinding the face of the tooth on straight tooth cutters only

2. To finish grind the rake angle and face of the tooth, revolve the cutter into the wheel by means of the micrometer adjustment on the tooth rest holder. *Do not* adjust the saddle, as this would change the rake angle of the cutter. Use the same wheel as for operation 1.

3. The third operation, grinding the back of the tooth, wears away wheels very rapidly. For this reason, two methods are shown. Figure 99C shows the operation with a new wheel Print No. 12Y-155, while Figure 99B shows the operation with a worn-out cup wheel Print No. 11Y-120 mounted on the spindle. The latter is recommended for the majority of shops, as there are usually plenty of these worn wheels which would otherwise be discarded. Grind one tooth at a time, in increments of about .002", until the width at the periphery approximately equals that of a new cutter. This width is an important factor in the strength of the cutter; and it must not be too narrow or the cutter may break in use.

4. Now proceed with the conventional sharpening operation of grinding the secondary and primary clearances.

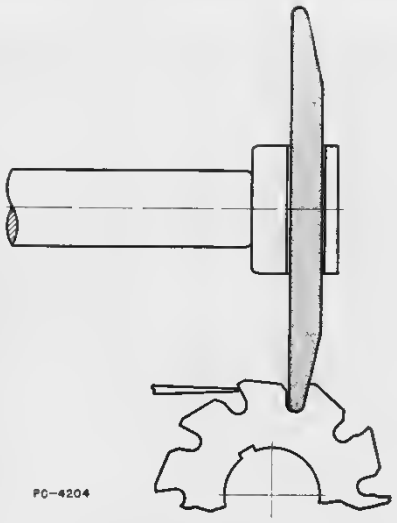


Figure 99A
Second Operation in Salvaging Cutters

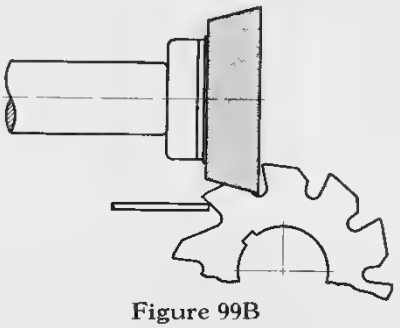


Figure 99B
Third Operation, With Worn-Out Cup Wheels

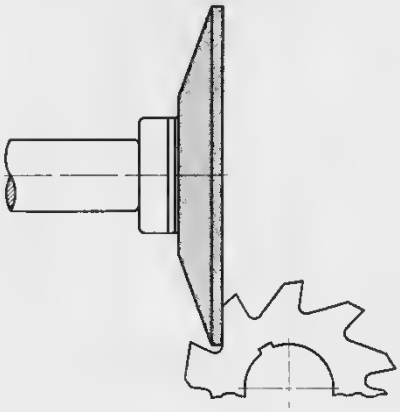


Figure 99C
Third Operation, With Wheel Print No. 12Y-155

Helical End Mills. Most end mills are not worth the price of salvaging However, the operation may be advisable if the end teeth are broken on a new cutter.

The first step is to cut off the damaged end of the cutter (Figure 100A) Wheel Print No. 1Y (6" diam. x ⅛" face x 1¼" hole) is recommended. Do not feed too slowly or the wheel will glaze and the cutter will burn.

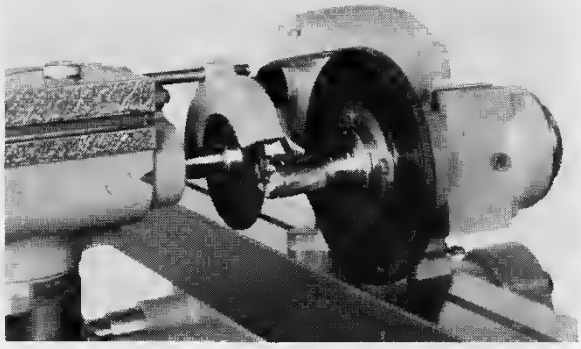


Figure 100A
Cutting Off the Broken Teeth of a Helical End Mill

After the end is cut off, it becomes necessary to recut the teeth in the end of the cutter:

1. Mount the cutter in the workhead.
2. Use the dish wheel, (Print No. 12Y-155).
3. Mount the universal tooth rest on the workhead with the blade bearing against the face of one cutter tooth
4. Swivel the eccentric wheelhead, to the "O" setting
5. With a combination square, set a tooth face square with the table.
6. Swivel the workhead or table to the helix angle of the cutter.
7. Set one table stop dog to limit the depth of cut.
8. Grind the gullet for one tooth. Feed the cutter straight into the wheel, and intermittently to avoid burning. Work on two opposing teeth first.
9. When grinding the remaining teeth, it may be necessary to raise the wheel head so that the wheel clears the previously ground teeth
10. After recutting the end teeth, they may be sharpened in the usual manner.

ATTACHMENTS

Surface Grinding Attachment. The surface grinding attachment is used for grinding flat forming tools, lathe tools, planer tools, flat thread chasers, drifts, chisels, and work of a like nature. The attachment consists of a swivel vise with an intermediate support between the vise and the base, which allows the vise to be swiveled in two planes (Figure 101C). The regular work head support may be removed and placed between the vise support and the base, making the vise adjustable in three planes (Figure 101A). It is then possible to completely grind almost any flat tool without removing it from the vise, thereby maintaining greater accuracy between the ground surfaces.

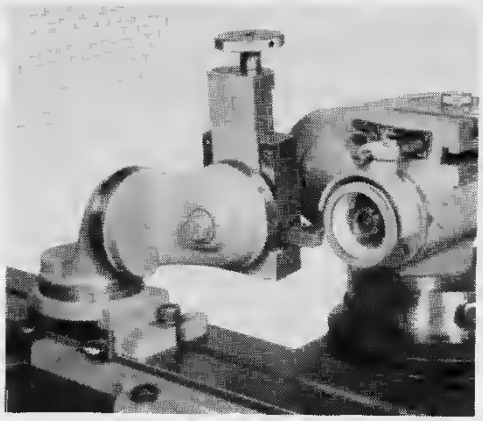


Figure 101A
Surface Grinding Attachment Set in Vertical Position for Grinding a Lathe Tool

The intermediate support may be removed and the vise body mounted directly on its base (Figure 101B) which allows a maximum distance of $6\frac{3}{8}''$ under the periphery of a 6″ diameter grinding wheel to top of the vise. With the eccentric wheelhead, upper swivel, swiveled to the extreme position toward the sliding table, and the wheelhead set at 90°, work up to 4″ wide can be ground on this setup If the work is rigid enough to permit an overhang, the grinding width can be increased to approximately 6″. The vise jaws are 4″ wide by $\frac{15}{16}''$ deep, and open up to $2\frac{1}{2}''$.

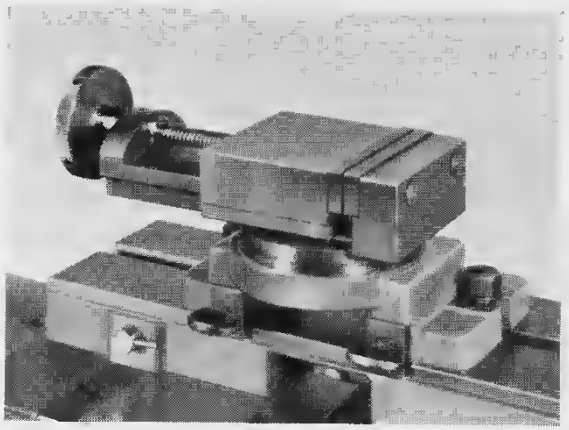


Figure 101B
Vise in Horizontal Position

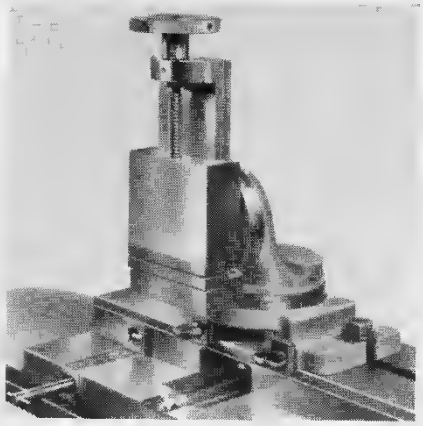


Figure 101C
Vise in Vertical Position

Gear Cutter Grinding Attachment. The attachment shown in Figure 102A is very useful in sharpening form relieved form cutters. This attachment consists of a base, upper swivel, pawl, centering gage and five adapter bushings.

The cutter stud on the attachment is 7/8" diameter, but adapter bushings of 1", 1¼", 1½", 1¾" and 2" outside diameter are supplied for cutters with these hole diameters. (Metric sizes are stud 22 mm and bushings 27 mm, 32 mm, 40 mm, 45 mm and 50 mm O. D.) Gear cutters or any cutter of similar design up to 8¾" outside diameter and up to 2" hole diameter can be ground on this attachment.

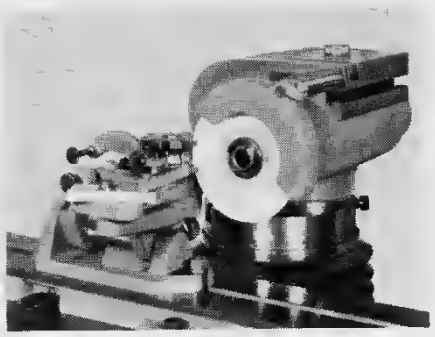


Figure 102A
Gear Cutter Grinding Attachment

Refer to pages 56-59 for basic instructions for sharpening form relieved cutters

Face Mill Grinding Attachment. Face mills up to 8" diameter may be ground on the standard workhead of the machine without the use of a special attachment, with raising block, up to 10" diameter Larger cutters up to 18" diameter, may be ground on the No. 2 Cutter and Tool Grinder by using the face mill grinding attachment, which was designed especially for large diameter mills. Refer to pages 60-63 for basic instructions for sharpening large diameter face mills

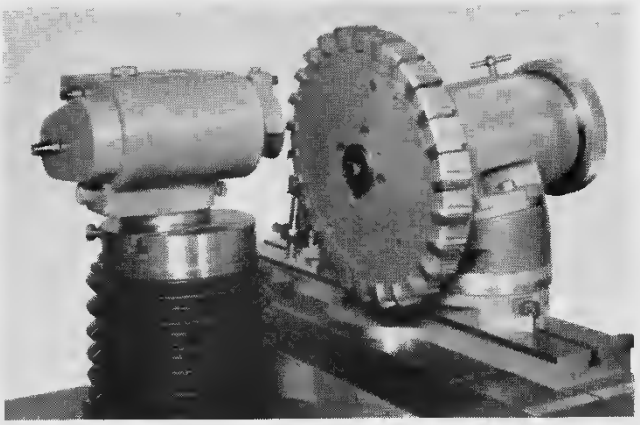


Figure 102B
Face Mill Grinding Attachment

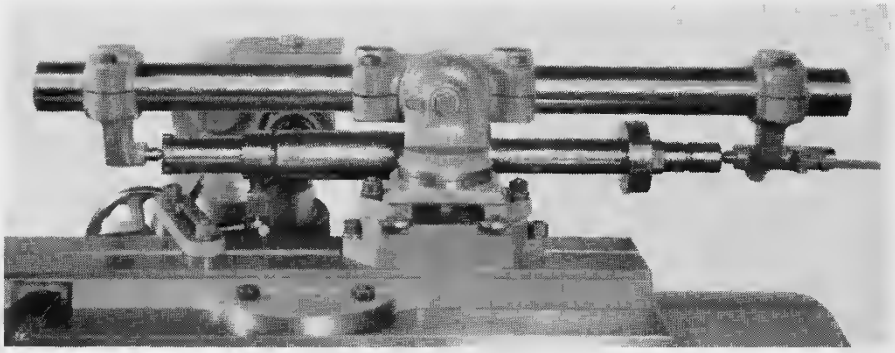


Figure 103A
Long Reamer Grinding Attachment

Long Reamer Grinding Attachment. This attachment is useful in grinding long lining reamers, boring bars, extension taps, stay-bolt taps, cutters on arbors when concentricity is important, and long work of like nature The method of grinding the part is not altered due to using this attachment To avoid excessive overhang, and to prevent tipping of the table and slide, the table can be swiveled 180° The attachment centers (without the raising blocks) are 7/8″ above the level of the table. The maximum cutter diameter which will clear the supporting bracket is 6″, but if the cutter is located between the support and the right or left hand tailstock, a 7″ diameter cutter will clear Work up to 34″ long can be placed between the attachment centers

Blade Grinding Attachment. This attachment was designed for the purpose of grinding centerless grinder work rest blades When setting up, the only precaution necessary is to see that the slot for holding the blade and also the bottom of the attachment is clean before mounting and clamping the blade in position

The angle of a centerless grinder blade varies according to the diameter of the work to be ground, the type of work, and the material. Thirty degrees has been found to be the best blade angle for general purpose centerless grinding, but for large diameters, the angle may be reduced to as low as 10 degrees. On the other hand, an oil groove or oil hole in the work will cause out-of-roundness, and to correct this fault it is necessary to reduce the wheel pressure by grinding a steeper angle on the blade.

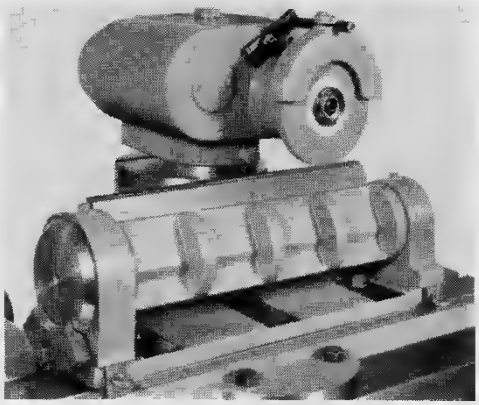


Figure 103B
Blade Grinding Attachment

No. 1 Radius Grinding Attachment. For quickly and accurately sharpening small ball-end cutters, double-end cutters, and die-sinking cutters having straight or helical flutes. With the addition of motor drive parts, it may also be used for cylindrical grinding straight and taper tracer fingers for die-sinking machines. Refer to pages 68-71 for basic instructions for using this attachment.

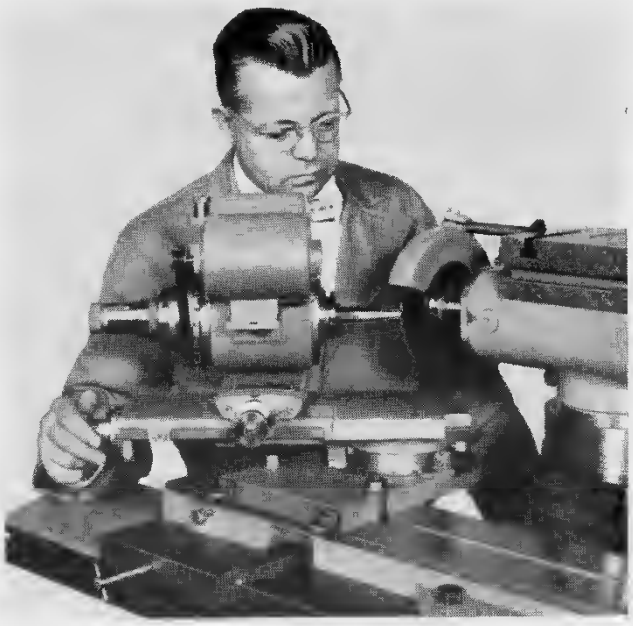


Figure 104A
No. 1 Radius
Grinding Attachment

No. 2 Radius Grinding Attachment. This attachment is designed for grinding radii (90 degree arc) on the teeth of shell end mills, face mills and similar cutters. It has a capacity of 0 to 12″ diameter cutters, and will grind radii of 0 to one inch. However, the ingenious operator can grind larger radii by adjusting the attachment slides beyond the range of the micrometer. The cutter can first be ground on its diameter, while mounted in the attachment as illustrated here, and then follow with the radius and face grinding operation in one pass. In this way, an accurate radius and a perfect blend will be obtained. Refer to pages 72-75 for basic instructions for using this attachment.

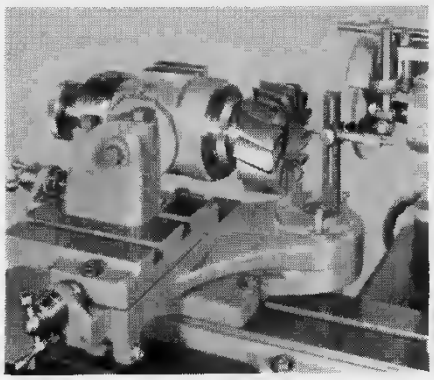


Figure 104B
No. 2 Radius
Grinding Attachment

Cylindrical Grinding Attachment. The cylindrical grinding attachment can be used for all types of straight or taper cylindrical grinding; such as reamers, lathe centers, mandrels, tap or drill shanks; and for facing operations, such as cutter hubs, gear shaper cutters, collars, nuts, etc. Small machine parts, made in small quantity or experimental lot sizes may also be economically ground with the cylindrical grinding attachment, if dry grinding is permissible. Refer to pages 64 to 65 for basic instructions for using this attachment

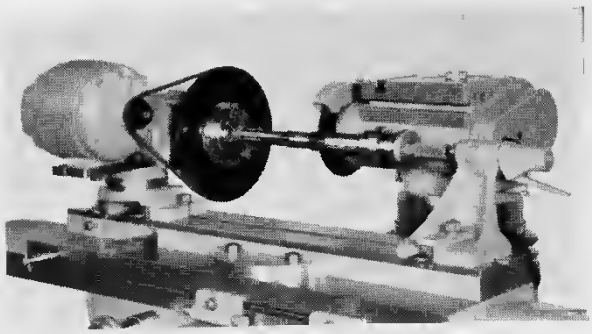


Figure 105A
Cylindrical
Grinding Attachment

Internal Grinding Attachment. This attachment is ordinarily used for grinding holes in cutters, jig bushings, arbor collars, etc., and is generally used in conjunction with cylindrical grinding attachment. The attachment spindle is driven by a positive drive belt from a gear tooth pulley mounted on the grinding wheel spindle, providing approximately a 23,000 rpm for small internal grinding wheels. It is available for machines having the conventional double end spindle or precision tilting wheelhead arrangement. Refer to pages 66 to 67 for basic instructions for using this attachment

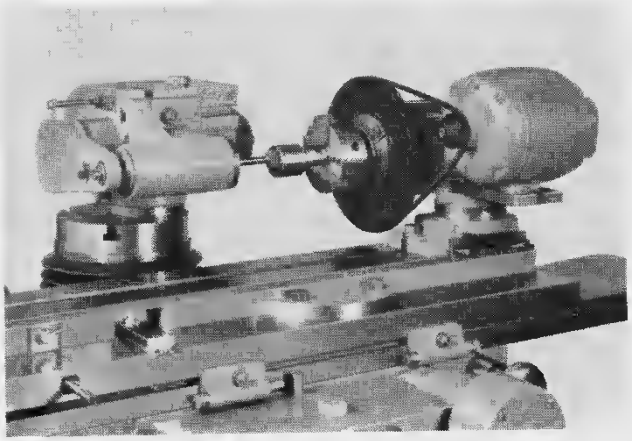


Figure 105B
Internal
Grinding Attachment

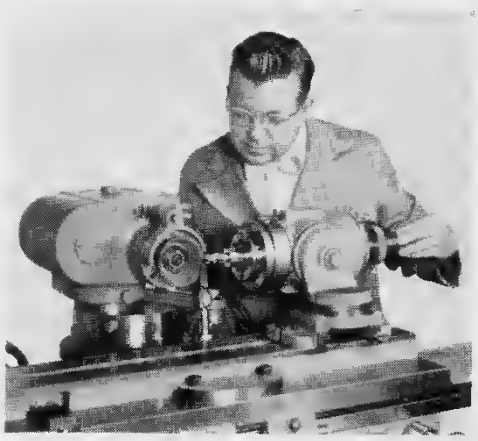


Figure 106A
Small End Mill
Grinding Attachment

Small End Mill Grinding Attachment. Refer to pages 37-39 for basic instructions for sharpening plain milling cutters with helical teeth. The table is locked against movement, with the aid of the "T" screw for the rear table control knob (Figure 18B), when the Small End Mill Grinding Attachment is used The workhead spindle is also locked in position. A bar, which slides in a bush inserted in the No. 12 B. & S. taper bore of the workhead spindle, has a No. 7 B. & S. or No. 2 Morse taper bore in the front end for holding small diameter end mills (Figure 106B). This bar is moved axially and rotated by hand A stop collar is secured to the bar to govern its length of travel. Adjust for the clearance angle by using the dial on the workhead spindle

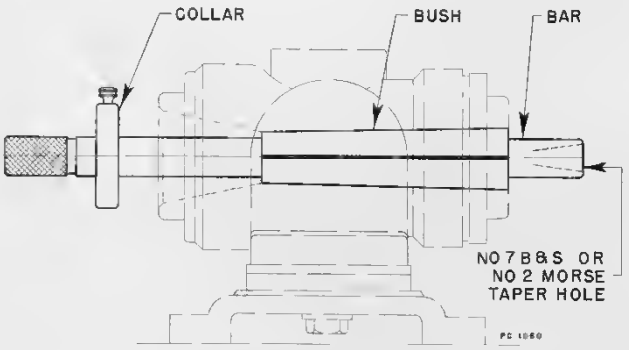


Figure 106B
Line Drawing Showing Small End Mill Grinding Attachment
Mounted in Workhead.

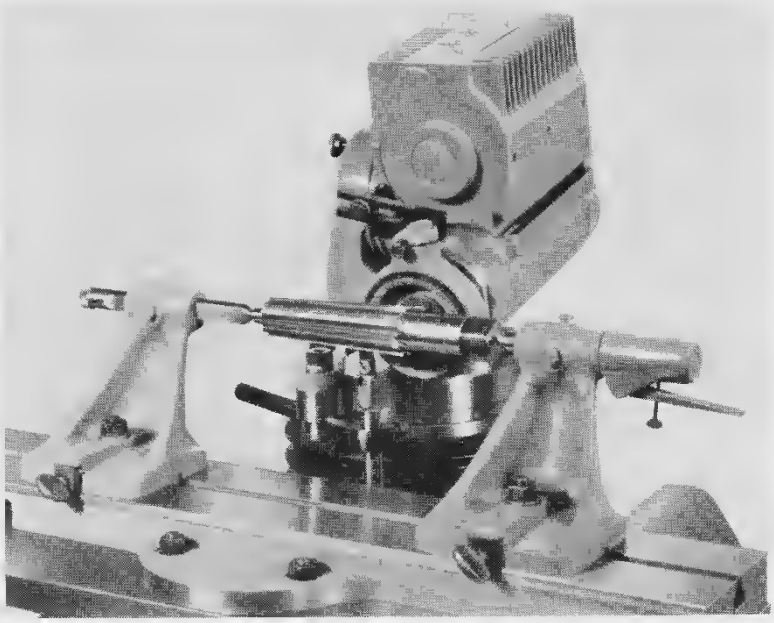


Figure 107A
Motorized Tilting Wheelhead

CINCINNATI® Motorized Tilting Wheelheads are desirable where a large volume of angular cutters and tapered reamers must be ground with a "flatland" clearance. The illustration above clearly shows a typical setup for the grinding of a tapered reamer using the Motorized Tilting Wheelhead. The head tilts 15° below center and 15° above center while still retaining all the advantages of the 360° column swivel and 360° eccentric swivel. When the head is not tilted, a positive positioning plunger accurately locks the head in a zero position. This totally enclosed, instantly reversible 1 hp motor drives the spindle through power grip belt and pulleys to provide two speeds, 3890 and 6530 rpm. A 4" extended spindle is available for the wheelhead and can be readily interchanged with the conventional spindles. These cartridge type spindles are anti-friction in design. Equipment supplied with the standard No. 2 Cutter and Tool Grinder such as, wheels, wheel guards, wheel collets are interchangeable with the Tilting Wheelhead arrangement.

Dust Collectors. As a health measure, dust collectors should be connected to all machines. Those grouped together may be serviced with a central system, while isolated machines should be equipped with an individual unit. Several types of the latter are available, one of which is illustrated in Figure 108A.

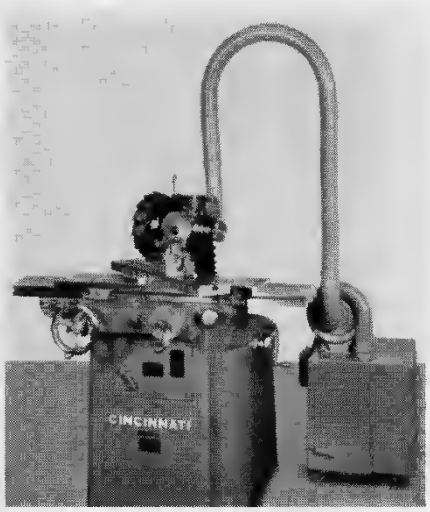


Figure 108A
Dust Collector

ADJUSTMENTS

Adjusting the Workhead Spindle Bearings. An adjusting nut for this operation will be found at the rear end of the spindle, (Figure 109A). Proceed in the following manner

1. Loosen screw "A" (Figure 109A) through the adjusting nut. There are three of these screws.
2. Lightly tap the nut to break its grip with the spindle.
3. Hold the spindle with one hand and turn the adjusting nut with the other, until there is no evidence of looseness.
4. Re-tighten three screws "A"

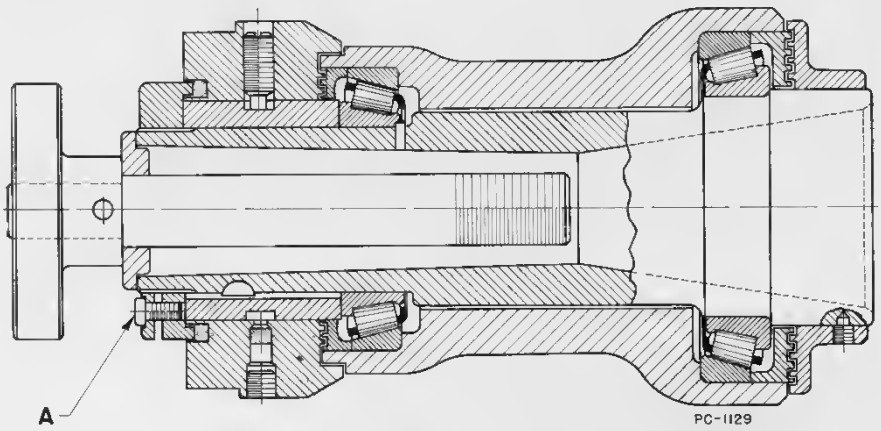


Figure 109A. Section Through the Workhead Spindle

Adjusting the Tange-Bar Taper Setting Device. Taper (if present) after a test grind on the workpiece, can be eliminated by adjusting the Tange-Bar Taper Setting Device. Loosen swivel clamping bolts (Figure 24A). Loosen set screw on left rear of swivel table (Figure 109B). Mount an indicator on the eccentric wheelhead, with the indicator stem lightly touching the table, traverse the slide back and forth aligning the table until indicator remains at zero. Tighten swivel clamping bolts and set screw. Indicate table again before removing indicator to be sure table has not moved from tightening clamping bolts and set screw.

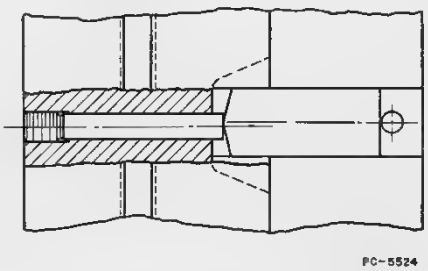


Figure 109B
Tange-Bar Taper Setting Device Adjusting Screw

REPLACING THE WHEELHEAD SPINDLE (Anti-Friction)

If the wheel spindle bearings should become worn or damaged in any way, do not try to replace them with standard commercial bearings The spindle is equipped with precision preloaded ball bearings, made especially for this particular application, and fitted by thoroughly experienced assemblers. We strongly recommend that you remove the spindle unit and send it to us when it is in need of repairs To replace the wheelhead spindle proceed as follows:

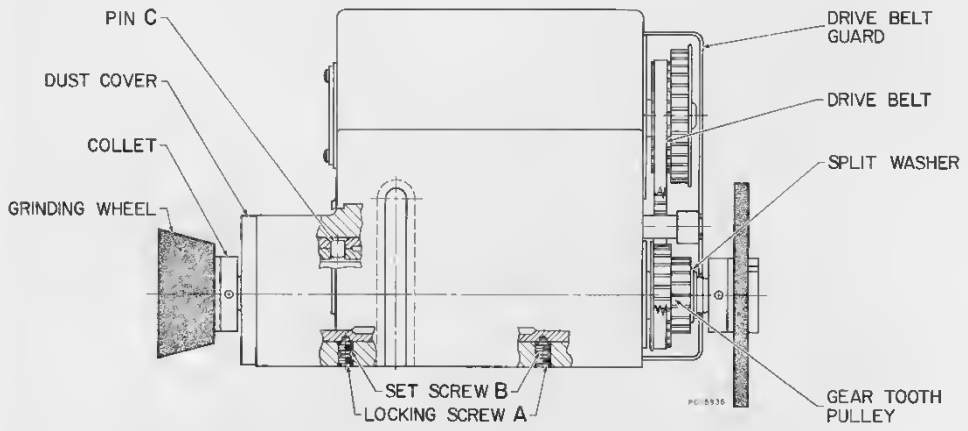


Figure 110A. Grinding Wheel Spindle (Anti-Friction)

Remove Old Spindle

1 Remove grinding wheels, collets and wheel guards from both ends of grinding wheel spindle (Figure 110A)

2 Remove main drive belt guard from right-hand side of wheelhead.

3. Remove power grip belt.

4. Gear tooth pulley* can be slipped off the spindle by first removing the split ring washer

5. Remove the two locking screws "A" and two set screws "B" (Figure 110A).

6. The old spindle can now be removed by pulling it out from the right end of the wheelhead. The spindle can also be pulled out from left end of the wheelhead by first removing the dust cover held on by four screws.

*Note: It is not necessary to remove the driven gear tooth pulley to 'pull' the spindle. However, it is more convenient to remove the pulley at this time because the grinding wheel spindle is firmly held in position, eliminating an unnecessary operation after spindle has been removed.

Install New Spindle

1. Clean spindle hole in wheelhead.
2. Unpack new spindle, being careful not to bump it or allow it to come in contact with dirt or grit, etc
3. Remove slushing oil Do not use solvent, instead use a clean dry cloth
4. Insert the new spindle in either the right or left end of the wheelhead, with the end for the tooth pulley to the right when facing the front of the machine Important—When inserting the new spindle in the wheelhead it should be rotated so pin "C" (Figure 110A) will not interfere with set screws "A" and "B"
5. Replace the gear tooth pulley and split ring washer.
6. Align spindle, utilizing a straight edge against side of gear tooth driver pulley on motor to side of driven gear tooth pulley on grinding wheel spindle
7. Spot new spindle, using a 5/16" drill through tap holes for screws "A" and "B" (Figure 110A). Care should be exercised in spotting new spindle so as not to move it out of alignment.
8. Replace set screws "B".
9. Replace locking screws "A"
10. Replace power grip belt
11. Replace drive belt guard.
12. If the old spindle was removed from the left end of the wheelhead, the dust cover held on by four screws, can now be assembled on the wheelhead.

TABLE OF GRINDING WHEELS AND THEIR USES
(See Figure 113A)

For Carbon Steel and High Speed Steel Cutters

Cincinnati Milling Machine Co. Size and Print Number	Uses
*6″ x ¾″ x 1¼″—12Y-155	Gear Cutters, Formed Cutters, Hobs, Taps, Boring Cutters
*3½″ x 1½″ x 1¼″—11Y-120	Reamers, Plain Helical Cutters, Slotting Cutters, Face Mills, Angle Mills, End Mills
*5″ x 1½″ x 1¼″—6Y-112	Flat Forming Tools, Lathe and Planer Tools, Screw Machine Tools, Work Rest Blades, Straight Edges, Gages, Drifts
*6″ x ½″ x 1¼″—1Y	Cylindrical Grinding, Surface Grinding.
†⅝″, ¾″ or 1″ x ½″ x ¼″—1Y	Internal Grinding
8″ x ⅜″ x 1¼″—1Y	Face Mills, Steep Angle Helical Cutters.
*6″ x ⅛″ x 1¼″—1Y	Plain Helical Cutters, Reamers, End Mills, Angle Mills
8″ x 1/16″ x 1¼″—1Y	Cutting Off Bar Stock, Tubing, Damaged Cutters, Etc.

*Supplied as standard equipment with the Plain Machines

†Supplied as standard equipment with the Universal Machines in addition to those supplied with the Plain Machine

Note: It is contrary to the Safety Code to use standard wheel collets and wheel pulleys, supplied with the machine, for 8″ diameter wheels. Collets and wheel pulleys for 8″ diameter wheels can be supplied at extra cost See items 11, 12 and 13, under extra cost equipment near end of book

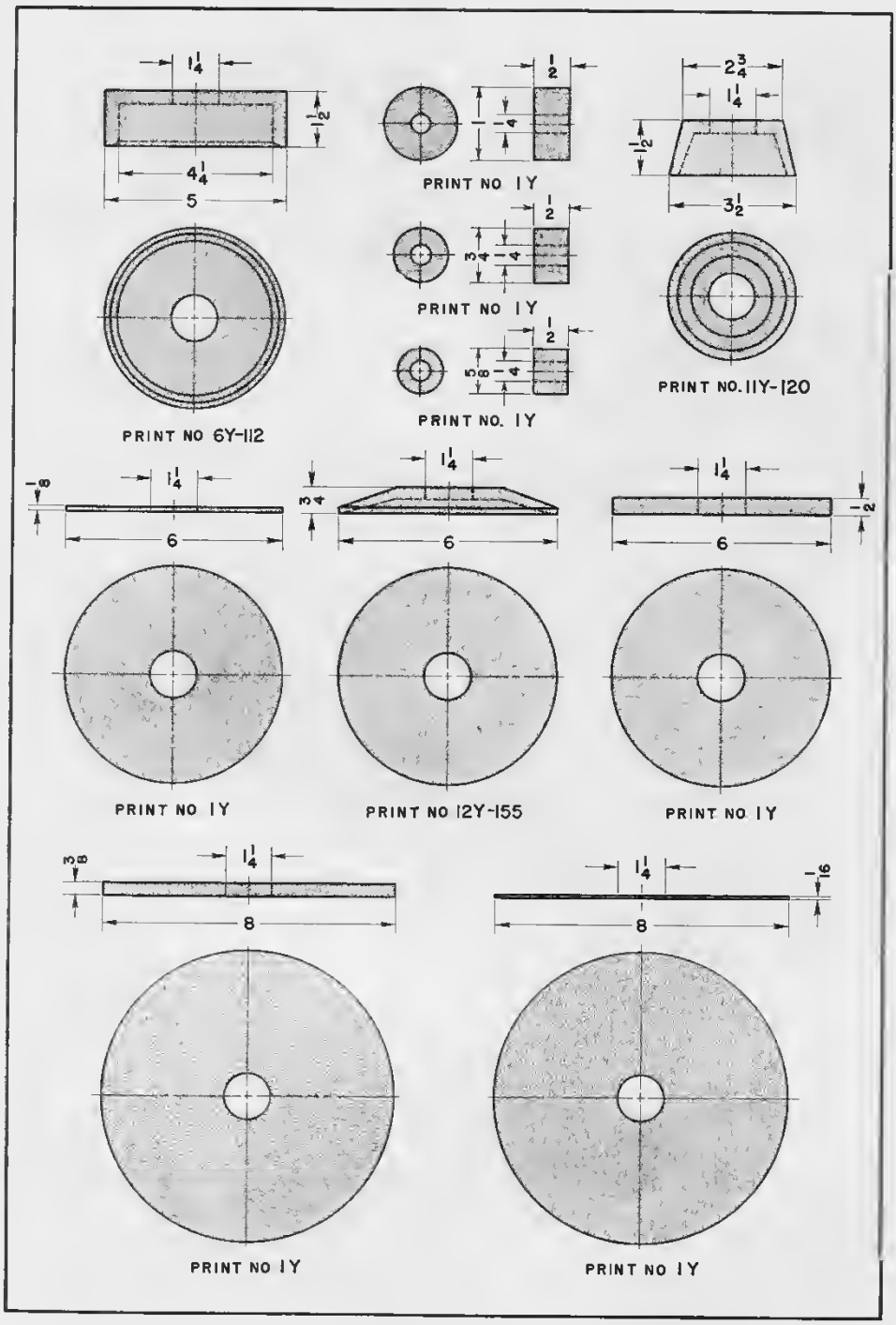


Figure 113A
Grinding Wheels Used on CINCINNATI No. 2
Cutter and Tool Grinder

Corner Angle Clearance. To use the table select the desired true clearance angle and corner angle. At the horizontal and vertical intersection of these values read correct settings for radial roll and axial tilt. For example for 5° true clearance and 30° corner angle, the radial roll is 4.3° and the axial tilt is 2.5°

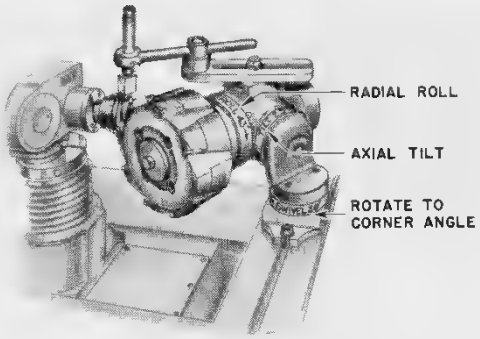


Figure 114A
Set-up for Proper Corner Clearance

CORNER ANGLE

DESIRED TRUE CLEARANCE ANGLE	5°		10°		15°		20°		22½°		25°		30°		35°		40°		45°		DESIRED TRUE CLEARANCE ANGLE
	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	
½°	0	0.5	0.1	0.5	0.1	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.3	0.4	0.3	0.4	0.3	0.4	0.4	0.4	½°
1°	0.1	1.0	0.2	1.0	0.3	1.0	0.3	0.9	0.4	0.9	0.4	0.9	0.5	0.9	0.6	0.8	0.6	0.8	0.7	0.7	1°
1½°	0.1	1.5	0.3	1.5	0.4	1.5	0.5	1.4	0.6	1.4	0.6	1.4	0.8	1.3	0.9	1.2	1.0	1.1	1.1	1.1	1½°
2°	0.2	2.0	0.3	2.0	0.5	1.9	0.7	1.9	0.8	1.8	0.8	1.8	1.0	1.7	1.2	1.6	1.3	1.5	1.4	1.4	2°
2½°	0.2	2.5	0.4	2.5	0.6	2.4	0.9	2.4	1.0	2.3	1.1	2.3	1.2	2.2	1.4	2.1	1.6	1.9	1.8	1.8	2½°
3°	0.3	3.0	0.5	3.0	0.8	2.9	1.0	2.8	1.2	2.8	1.3	2.7	1.5	2.6	1.7	2.5	1.9	2.4	2.1	2.1	3°
3½°	0.3	3.5	0.6	3.4	0.9	3.4	1.2	3.3	1.3	3.2	1.5	3.2	1.8	3.0	2.0	2.9	2.3	2.7	2.5	2.5	3½°
4°	0.3	4.0	0.7	3.9	1.0	3.9	1.4	3.8	1.5	3.7	1.7	3.6	2.0	3.5	2.3	3.3	2.6	3.1	2.8	2.8	4°
4½°	0.4	4.5	0.8	4.4	1.2	4.3	1.6	4.2	1.7	4.2	1.9	4.1	2.3	3.9	2.6	3.7	2.9	3.5	3.2	3.2	4½°
5°	0.4	5.0	0.9	4.9	1.3	4.8	1.7	4.7	1.9	4.6	2.1	4.5	2.5	4.3	2.9	4.1	3.2	3.8	3.5	3.5	5°
5½°	0.5	5.5	1.0	5.4	1.4	5.3	1.9	5.2	2.1	5.1	2.3	5.0	2.8	4.8	3.2	4.5	3.5	4.2	3.9	3.9	5½°
6°	0.5	6.0	1.0	5.9	1.6	5.8	2.1	5.6	2.3	5.6	2.5	5.4	3.0	5.2	3.5	4.9	3.9	4.6	4.3	4.3	6°
6½°	0.6	6.5	1.1	6.4	1.7	6.3	2.2	6.1	2.5	6.0	2.8	5.9	3.3	5.6	3.8	5.3	4.2	5.0	4.6	4.6	6½°
7°	0.6	7.0	1.2	6.9	1.8	6.8	2.4	6.6	2.7	6.5	3.0	6.4	3.5	6.1	4.0	5.8	4.5	5.4	5.0	5.0	7°
7½°	0.7	7.5	1.3	7.4	2.0	7.3	2.6	7.0	2.9	6.9	3.2	6.8	3.8	6.5	4.3	6.2	4.8	5.8	5.3	5.3	7½°
8°	0.7	8.0	1.4	7.9	2.1	7.7	2.8	7.5	3.1	7.4	3.4	7.3	4.0	6.9	4.6	6.6	5.2	6.2	5.6	5.6	8°
9°	0.8	9.0	1.6	8.9	2.4	8.7	3.1	8.5	3.5	8.3	3.8	8.2	4.5	7.8	5.2	7.4	5.8	6.9	6.4	6.4	9°
10°	0.9	10.0	1.8	9.9	2.6	9.7	3.5	9.4	3.9	9.3	4.3	9.1	5.1	8.7	5.8	8.2	6.5	7.7	7.1	7.1	10°
11°	1.0	11.0	1.9	10.8	2.9	10.6	3.8	10.4	4.3	10.2	4.7	10.0	5.6	9.6	6.4	9.1	7.1	8.5	7.8	7.8	11°
12°	1.1	12.0	2.1	11.8	3.2	11.6	4.2	11.3	4.7	11.1	5.2	10.9	6.1	10.4	7.0	9.9	7.8	9.3	8.6	8.6	12°
13°	1.2	13.0	2.3	12.8	3.4	12.6	4.5	12.3	5.1	12.1	5.6	11.8	6.6	11.3	7.6	10.7	8.5	10.0	9.3	9.3	13°
14°	1.2	14.0	2.5	13.8	3.7	13.5	4.9	13.2	5.5	13.0	6.0	12.7	7.1	12.2	8.1	11.5	9.1	10.8	10.0	10.0	14°
15°	1.3	15.0	2.7	14.8	4.0	14.5	5.3	14.2	5.9	13.9	6.5	13.7	7.6	13.1	8.7	12.4	9.8	11.6	10.7	10.7	15°
	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	
	85°		80°		75°		70°		67½°		65°		60°		55°		50°		45°		

CORNER ANGLE

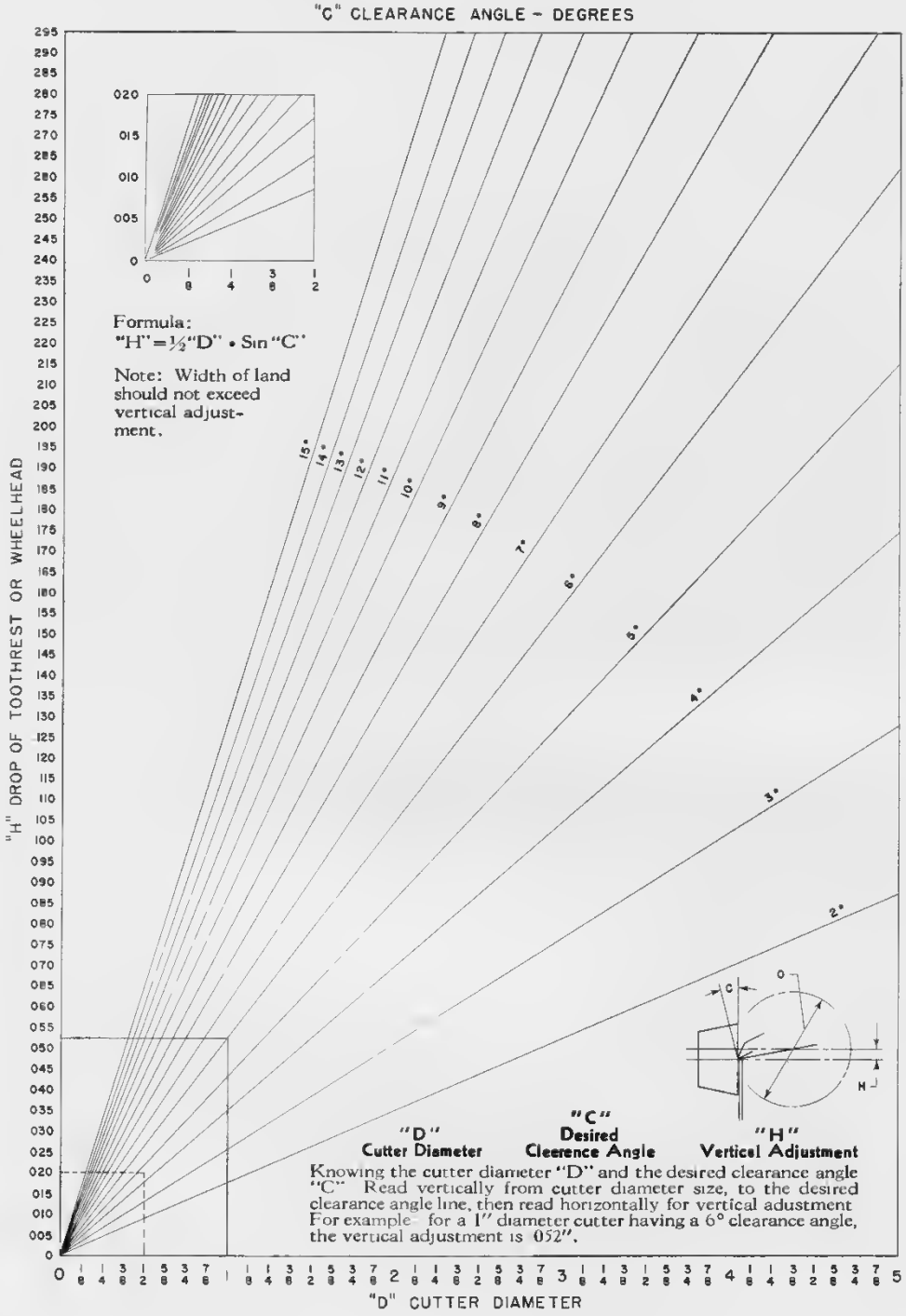


Figure 115A
Clearance Angle Chart

EQUIPMENT SUPPLIED AT EXTRA COST
Not Included in Price of Standard (Basic) Machine

PLAIN MACHINE ONLY

1. **Cylindrical Grinding Attachment.** Includes 4" 3 Jaw Universal Chuck with 2 sets of non-reversible jaws, Chuck Adapter, Chuck Wrench, Vee Belt, Plate and Screws for Motor Base, Pulley fitted with two Clamps, Collar, and Dog, Universal Grinding Dog, and Complete Electrical Equipment. Specify taper in workhead spindle (Modified 12 B. & S. or No. 5 Morse). Code Name—CYLAT.

2. **Surface Grinding Attachment.** Includes Vise, Intermediate Support, Two Tee-Blots, and Base Plate. Code Name—SURAT

   (a) For additional intermediate support for above attachment see item 34.

3. **Internal Grinding Attachment.** Includes two removable type quills, type one for ¼" diameter hole wheels; type two for ⅜" diameter hole wheels; three straight grinding wheels, print No. 1Y (1" x ½" x ⅜" hole) No. 1Y (¾" x ½" x ¼" hole) and No. 1Y (⅝" x ½" x ¼" hole); pulley for wheel spindle belt; belt guard; support, screw and nut (Attachment requires use of cylindrical grinding attachment) Code Name—UABCD.

4. **Gear Cutter Sharpening Attachment.** Including Gage, Pawl, T-Bolts, and Five Cutter Bushings. Specify English or Metric Code Name—GERAT.

English	Metric
1" O.D. x ⅞" Bore.	27mm. O.D. x 22mm. Bore.
1¼" O.D. x ⅞" Bore	32mm. O D. x 22mm. Bore
1½" O.D. x ⅞" Bore.	40mm. O D. x 22mm. Bore
1¾" O.D. x ⅞" Bore.	45mm. O.D. x 22mm. Bore.
2" O.D. x ⅞" Bore.	50mm. O D x 22mm Bore

PLAIN OR UNIVERSAL MACHINES

1. **No. 1 Radius Grinding Attachment.** Capacity—0" to 2" radii and 4" maximum cutter diameter. Attachment spindle has No. 12 B. & S. or No. 5 Morse Taper Specify which taper is desired at time order is placed.

   Standard Attachment. Code Name—RAATT.

   Additional Equipment for doing straight and cylindrical grinding.

   (a) Motor Drive Equipment, Complete Specify current characteristics Code Name—MOQUS.

   (b) Basic Parts required for grinding straight shank cutters when either item "C" or "D" is purchased. Code Name—BAPAR.

   (c) Sleeve for Grinding Large Straight Shank Cutters—Item "b" above must also be purchased.

   Capacity { ¾" and ⅞" diam. shanks. Code Name—SLESH.
   1" and 1¼" diam. shanks. Code Name—SLECU

(d) Sleeve and Draw-in Bolt for Draw-in Collets—Item "b" must also be purchased. See item "e" below for Collets Code Name—SLEBO

(e) Draw-in Collets for Grinding Small Straight Shank Cutters Sizes, $\frac{1}{8}$", $\frac{3}{16}$", $\frac{1}{4}$", $\frac{5}{16}$", $\frac{3}{8}$", $\frac{7}{16}$", $\frac{1}{2}$", $\frac{9}{16}$" and $\frac{5}{8}$".

(f) Collets for Grinding Taper Shank Cutters—fits into attachment spindle. Specify taper in attachment spindle (modified No. 12 B. & S. or No. 5 Morse). Same as collets for standard workhead. (*See Item 15, page 119, concerning spindle bore openings*).

2. **No. 2 Radius Grinding Attachment.** Includes swivel housing, swivel table, top plate, workhead support, micrometer locating gage for setting 0" to 1" radii. Conventional workhead is used for holding cutter. Code Name—RAGAT.

   The following parts are included with the standard machine equipment and therefore are not included when supplying the attachment. Workhead spindle housing, draw-in bolt, and three reducing collets. If face mills are to be ground it will be necessary to purchase a Face Mill Adapter, item 27.

   Note—When supplied on a 24" Table Travel Machine, two 2" Raising Blocks are required. See item 33 page 122.

3. **Long Reamer Grinding Attachment.** Capacity—6" diam., 34" between centers. Code Name—TENEX.

4. **Face Mill Grinding Attachment.** Capacity—18" diam. cutters. Attachment includes base swivel plate, workhead, arbor for holding face mills (No. 50 Series National Standard taper). Code Name—RIFZ.

   (a) Adapter Plate, 8" diameter with $5\frac{1}{16}$" bore. Used for grinding large diameter cutters. Code Name—ADPLA.

   (b) Adapter Bushing, 2" O.D. with $1\frac{1}{2}$" bore. Code Name—ADTOO.

   (c) Adapter Bushing, $2\frac{1}{2}$" O.D. with $1\frac{1}{2}$" bore. Code Name—ADBUS.

5. **Indexing Attachment for Workhead.** Includes one 24-notched index plate. Code Name—RECBC.

   Extra Index Plates—Specify number of notches desired.

6. **Micrometer Table Positioning Attachment.** Operated by an accurate lead screw. Code Name—RECBF.

7. **Heavy Duty Tailstocks.** 16" swing, 19" between centers. Code Name—RECBA.

8. **2″ Extended (Filmatic) Grinding Wheel Spindle** on left end including long wheel guard holder. Standard length spindle on right end.—Filmatic or Anti-Friction

9. **4″ Extended (Anti-friction) Grinding Wheel Spindle** on left end including long wheel guard holder. Standard length spindle on right end

Note: The added 3½″ range available with the eccentric wheelhead mounting results in the new 2″ extension spindle providing 1½″ more range than the old 4″ extension spindle provided.

10. **Spindle Extensions.** (Includes longer wheel collet socket screw)

Length	Wheel hole size
2″	1¼″
4″	1¼″ (Includes long holder for wheel guard)

11. **Grinding Wheel Collets**

(a) Collets Parts

Name of Part	Wheel Print Number						
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Collet—Grinding Wheel	*	*	*	*	*	*	*
Nut—Wheel Collet	*	*	*	*	*	*	*
Washer—Wheel Collet	*	*	*	*	*	*	*
Spacer—⅛″ Thick	*	*	*		*		
Spacer—⅜″ Thick						*	*

One * Each.

(b) Collet Assembly

(a) Print No. 12Y-155 (6″ x ¾″ x 1¼″ Hole)
(b) Print No. 11Y-120 (3½″ x 1½″ x 1¼″ Hole)
(c) Print No. 6Y-112 (5″ x ½″ x 1¼″ Hole)
(d) Print No. 1Y (6″ x ½″ x 1¼″ Hole)
(e) Print No. 1Y (8″ x ⅜″ x 1¼″ Hole)
(f) Print No. 1Y (6″ x ⅛″ x 1¼″ Hole)
(g) Print No. 1Y (8″ x $\frac{1}{16}$″ x 1¼″ Hole)

Conforming to safety codes, large collets for wheels (e) and (g) are supplied.

12. **Wheel Pulleys**—8″ diameter grinding wheel. To conform to the safety code when using 8″ diameter grinding wheels, these pulleys should be used to maintain the correct surface speed of the wheel.

13. **Wheel Guard**—for 8″ diameter wheels. Code Name—NOSAB.

14. Standard Grinding Wheels without grinding wheel collet, wheel collet nut, wheel collet lock washer, or spacing collar. Standard Plain Machine includes one set of wheels consisting of a, b, c, d and g below. Universal machine includes one set of wheels consisting of a, b, c, d, e, g, h and j below.

(a) Print No. 12Y-155 dished—6" diam. x ¾" x 1¼" hole. Code Name—WED1S.
(b) Print No. 11Y-120 flaring cup—3½" diam. x 1½" x 1¼" hole. Code Name—WHECU.
(c) Print No. 6Y-112 straight cup—5" diam. x 1½" x 1¼" hole. Code Name—WEFIV.
(d) Print No. 1Y straight—6" diam. x ½" x 1¼" hole. Code Name —WHEIX.
(e) Print No. 1Y straight—1" diam. x ½" x ⅜" hole Code Name —LASSO.
(f) Print No. 1Y straight—8" diam. x ⅜" x 1¼" hole. Code Name —ATWHE.
(g) Print No. 1Y straight—6" diam. x ⅛" x 1¼" hole. Code Name —WHESI.
(h) Print No. 1Y straight—⅝" diam. x ½" x ¼" hole Code Name —WHENY.
(i) Print No. 1Y straight—8" diam. x $\frac{1}{16}$" x 1¼" hole (used for cutting off tubing, etc.). Code Name—WHEZA
(j) Print No. 1Y straight—¾" diam. x ½" x ¼" hole. Code Name —WHEAS.

15. Collets— Modified 12 B. & S. to 4 B. & S.
Modified 12 B. & S. to 5 B. & S.
Modified 12 B. & S. to 6 B. & S.
Modified 12 B & S. to 7 B. & S.
Modified 12 B. & S. to 9 B. & S.
Modified 12 B. & S. to 10 B. & S
Modified 12 B. & S. to 11 B. & S.
Modified 12 B. & S. to 1 Morse
Modified 12 B. & S. to 2 Morse
Modified 12 B. & S. to 3 Morse
Modified 12 B & S. to 4 Morse

Modified 5 Morse to 1 Morse
Modified 5 Morse to 2 Morse
Modified 5 Morse to 3 Morse
Modified 5 Morse to 4 Morse

Modified 5 Morse to 4 B. & S.
Modified 5 Morse to 5 B. & S.
Modified 5 Morse to 6 B. & S.
Modified 5 Morse to 7 B & S.
Modified 5 Morse to 8 B. & S.
Modified 5 Morse to 9 B & S.
Modified 5 Morse to 10 B. & S.
Modified 5 Morse to 11 B & S.

50 Series to 40 Series, National Standard Taper

Draw-in Bolt for 50 Series to 40 Series, National Standard Taper, reducing collet.

Notes: *Your selection of taper hole in workhead spindle governs which set of reducing collets and work center are supplied.

Collets, Key Nos. 13, 14 and 15, page 9 are interchangeable with the Standard Workhead and the present design of the No. 1 Radius Grinding Attachment, which have a spindle bore opening of 1.776". They cannot be used on the older type No. 1 Radius Grinding Attachment having a spindle bore opening of 1.797".

16. **Dust Exhaust System**
    (a) For 60 cycle current—direct drive (½ hp).
    (b) For 50 cycle current—belt drive (½ hp)

17. **Draw-in Collet Attachment**—5C or 6H collets Specify No. 12 B. & S taper or No. 5 Morse taper. (See item 18 below)

18. **Straight Cylindrical Collets**—for above attachment
    (a) 5C Type inch sizes from ⅛" to 1" in increments of 1/64"
    (b) 6H Type inch sizes from ⅛" through 1⅛" in increments of 1/64"
    (c) Decimal sizes from .125" to 1.125" for either 5C or 6H Specify exact size
    (d) Metric sizes from 3mm to 28 mm in increments of 1 mm

19. **Centerless Grinder Work Support Blade Grinding Attachment** —for blades up to 1" thick and 16½" long. Code Name—ATBLA.

20. **Spring Chuck and Spring Collets.** Chuck mounts directly into workhead spindle. Provides a quick and accurate method of holding straight shank cutters

21. **Small End Mill Grinding Attachment.** Complete. Includes three of the following items: **a** or **b** (not both), **c**, and **d** or **e** (not both). Code Name—SMETT.
    (a) Bar for End Mill Grinding Attachment with No. 7 B. & S hole Code Name—BEGA.
    (b) Bar for End Mill Grinding Attachment with No. 2 Morse taper hole. Code Name—BAGGA.
    (c) Collar for End Mill Grinding Attachment. Code Name—CEMRA
    (d) Sleeve for End Mill Grinding Attachment, No. 12 B. & S. taper outside Code Name—SLEMG
    (e) Sleeve for End Mill Grinding Attachment, No. 5 Morse taper outside. Code Name—SLEEG.

22. **Saw Grinding Attachment** (Face Chuck), complete. Code Name —FACHU.

23. **Stud for Holding Saws and Side Milling Cutters.** Code Name —STUHO.

    Capacity: Side Milling Cutters—$\frac{5}{8}$" maximum width with $\frac{7}{8}$" hole
    Saws—$\frac{3}{8}$" maximum width with $\frac{7}{8}$" or 1" hole

24. **Diamond Truing Rod**—with diamond. Code Name—RECBH.

25. **Tooth Rests**

    (a) Universal Tooth Rest—complete assembly including item (b) below.

    (b) Micrometer Adjustable Blade Holder with two blades—for Universal Tooth Rest.

    (c) Plain Tooth Rest—complete assembly including plate and item (d) below.

    (d) Plain Blade Holder with offset blade for Plain Tooth Rest

26. **Tooth Rest Blades**

    (a) Flat Top.

    (b) Round Top.

    (c) Off-set (For Plain Tooth Rest only).

27. **Face Mill Adapter.** For grinding face mills on either the standard Workhead or No. 2 Radius Grinding Attachment. Code Name—MILAD.

28. **4" 3-Jaw Universal Chuck.** Mounts in standard Workhead Spindle. Includes two sets of non-reversible jaws, internal and external. Chuck is fitted with No. 5 Morse or No. 12 B. & S. taper shank only. Specify which taper is desired. (Supplied as standard equipment on Universal Machine). Code Name—CHUGG.

29. **4" 4-Jaw Independent Chuck.** Reversible jaws. Mounts in standard Workhead Spindle. Specify taper hole in spindle (12 B & S. or 5 Morse). Code Name—RECBI.

30. **Raising Block, 2"** used with Workhead, Surface Grinding Attachment and Face Mill Grinding Attachment. Code Name—RABLO

31. **Belt, Tooth Grip, Main Drive.** Code Name—NOBEL.

32. Wrenches

(a) Double end—$\frac{7}{8}$″ x $\frac{9}{16}$″ opening (Part No. 19476).

(b) Collet nut wrench.

(c) T-wrench for wheel collet lock screw.

33. Cutter Sharpening Arbors—includes set of collars and nut.

(a) $\frac{7}{8}$″ diam. x $8\frac{3}{16}$″ usable cutter length.

(b) 1″ diam. x $8\frac{3}{16}$″ usable cutter length.

(c) $1\frac{1}{4}$″ diam. x $8\frac{3}{4}$″ usable cutter length.

(d) $1\frac{1}{2}$″ diam. x $8\frac{3}{4}$″ usable cutter length.

(e) 2″ diam. x $8\frac{3}{4}$″ usable cutter length.

34. Intermediate Support for Vise Body—includes bolt and washer. Code Name—RECBK.

35. Precision Motorized Tilting Wheelhead. Available in two styles, standard double end spindle, or double end 4″ extended spindle (4″ extended spindle on one end only), has an anti-friction spindle; 1 hp, 3450 rpm totally enclosed, instantly reversible motor; universal in a vertical plane, tilting 17° below center and 17° above center and swiveled 360 degrees horizontally; plunger provided for locking the wheelhead in a zero or horizontal position. Grinding wheel collet assemblies for mounting grinding wheels are the same as those supplied with the No. 2 Cutter Grinder

Standard Double End Anti-Friction Spindle. Code Name—YUXCY. Double End 4″ Extended Anti-Friction Spindle—4″ extended spindle one end only. Code Name—YUXCZ.

Note: A standard Internal Grinding Attachment is not suitable with this wheelhead. Consult factory for information.

No. 2 CUTTER and TOOL GRINDER with POWER TABLE TRAVERSE

★

Since the CINCINNATI No. 2 Cutter and Tool Grinder having power table traverse is operated slightly different than the standard No. 2 Cutter Grinder, the following pages briefly describe the operating functions. However, the information and instructions for the standard No. 2 Cutter Grinder printed in the preceding pages in this book also apply to this machine.

Figure 125A
CINCINNATI No. 2 Cutter and Tool Grinder
with Power Table Traverse

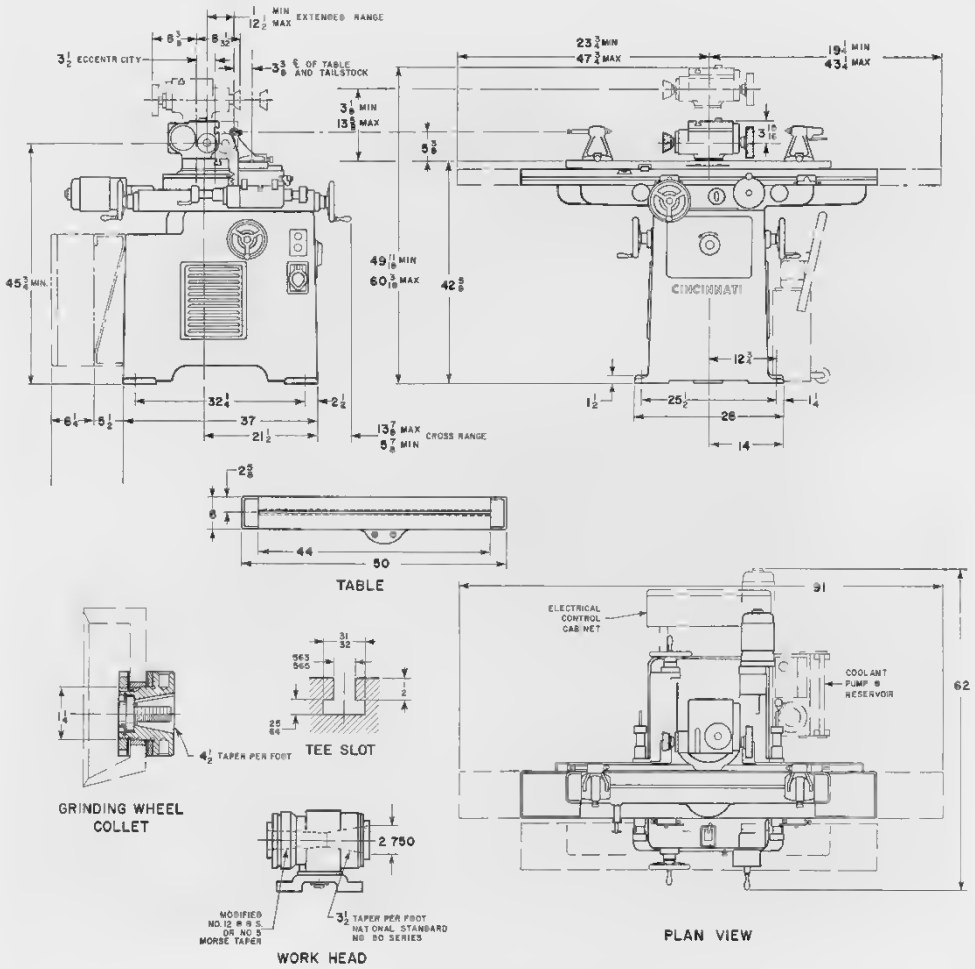


Figure 126A
Dimensional Drawing

GENERAL SPECIFICATIONS

CAPACITY	
Swing over Table	10½″ Diameter
Length, between Right and Left-Hand Tailstocks	33″
Length, between Tailstock and Workhead	28″
Face Mills on Workhead	10″ Diameter
Formed Cutters (using 6″ Wheel)	5½″ Diameter
TAPER HOLE IN WORKHEAD SPINDLE	
One End	No. 12 B. & S. or No. 5 Morse
Other End	No. 50 Series National Standard
TABLE	
T-Slots (Number and Size)	One .563″/.565″
Working Surface	6″ x 44″
RANGE	
Longitudinal Movement of Table	24″
Power Feed Range of Longitudinal Table Movement	7″ to 90″ per min.
Cross Movement of Table	10″
Cross Range Gained by Wheelhead Eccentricity	3½″
Cross Range Gained by Swivel Table	3½″
Total Extended Cross Range	17″
Table Swivels	180°
SWIVEL TABLE ADJUSTMENTS: (Taper Per Ft. on Diam.)	
Tange-Bar Taper Setting Device	Toward Wheelhead.....5″ Away from Wheelhead.....5″
Fine Taper Setting Device	Toward Wheelhead.....3″ Away from Wheelhead.....3″
Table Graduations in Center, in degrees	90°
Vertical Movement of Grinding Wheel Spindle	10½″
Swivel Movement of Grinding Wheel Spindle	360°
Maximum Distance Centerline Spindle to Top of Table	13⅝″
GRINDING WHEEL SPINDLE SPEEDS (two)	6530 rpm 3890 rpm
GRINDING WHEEL SURFACE SPEEDS 6″ Diam. Wheel	6110 fpm
GRINDING WHEEL SURFACE SPEEDS 3½″ Diam. Wheel	5985 fpm
FLOOR SPACE FOR OPERATING	62″ x 91″
SHIPPING DATA	
Net Weight (Approx.)	2500 lbs.
CODE NAME	NOPER

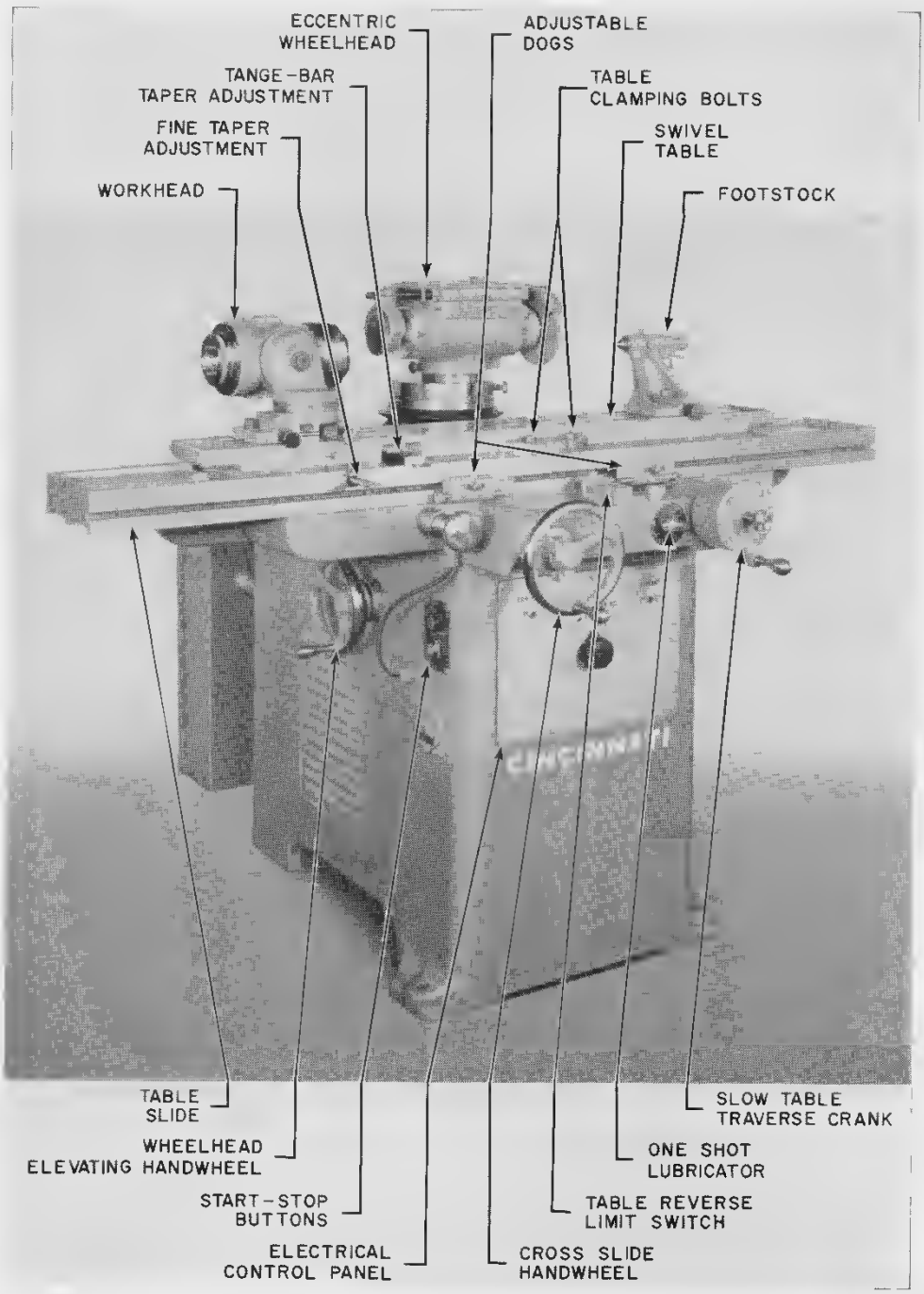


Figure 128A
Functional Diagram

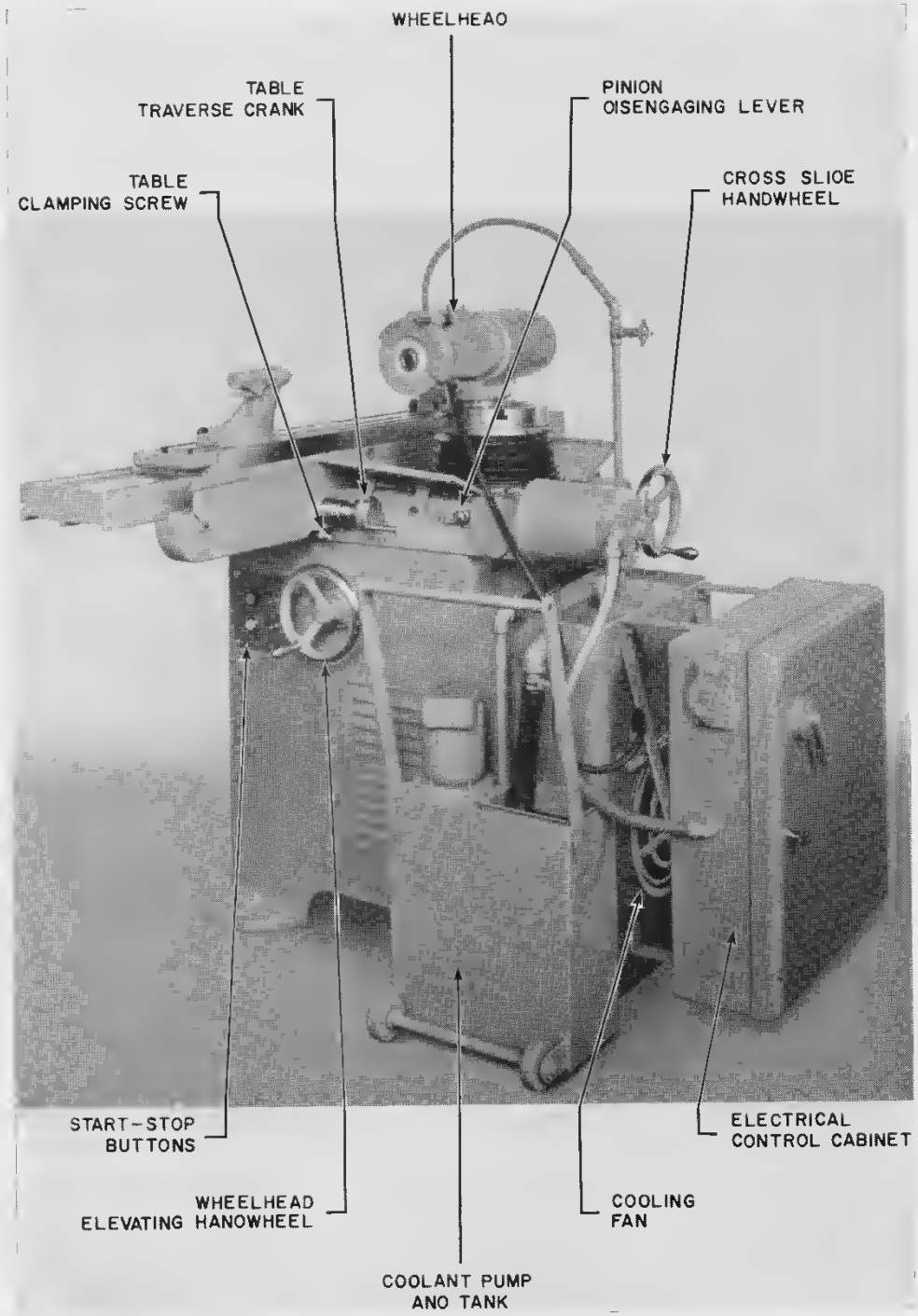


Figure 129A
Functional Diagram

OPERATING INSTRUCTIONS

Starting the Machine. When starting the machine for the day's work, fill all the oil holes and cups shown on the lubrication chart, pages 14 and 15. There is one additional oiler, not shown on this chart, for the Power Table Traverse Cutter Grinder for lubricating the Table Power Drive This station requires 2 or 3 shots of P-43, a light quality, sodium or lithium short fibre grease, with a hand grease gun, weekly. Before operating the oil-shot pump (Station 7) be sure to line up the two buttons indicated in the lubrication diagram, page 14 and the instruction plate attached to the machine.

Electrical Controls. All CINCINNATI No. 2 Cutter and Tool Grinders are individually motor driven, with the starting buttons built into compartments on both sides of the bed. The Power Table Feed controls and cutting fluid switch are built into a compartment on the front of the bed

Start and Stop Buttons. Spindle start and stop buttons are located on the right and left sides of the base (Figures 130A and 130B).

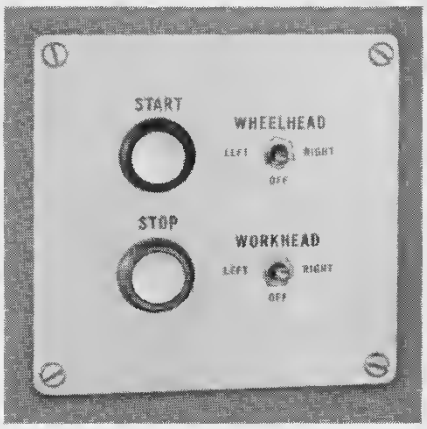


Figure 130A
Electrical Panel
at Right Side of Machine

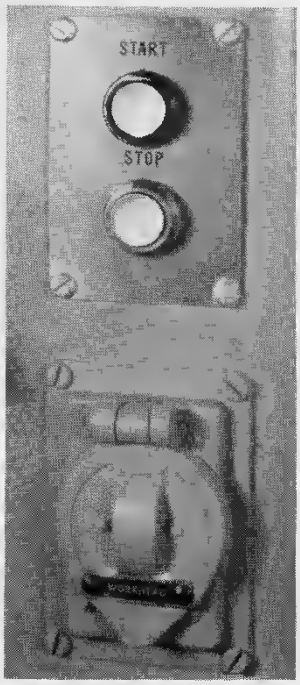


Figure 130B
Start and Stop Buttons and
Electrical Receptacle
at Left Side of Machine

Cylindrical Grinding Attachment. Means for supplying electric and controlling spindle rotation direction for the Cylindrical Grinding Attachment are built right into the base. A receptacle for plugging in this attachment is located on the left side of the base below the start and stop buttons, Figure 130B, the directional switch for the spindle rotation of the attachment is located on the same plate as the start and stop buttons on the right side of the base as shown in Figure 130A.

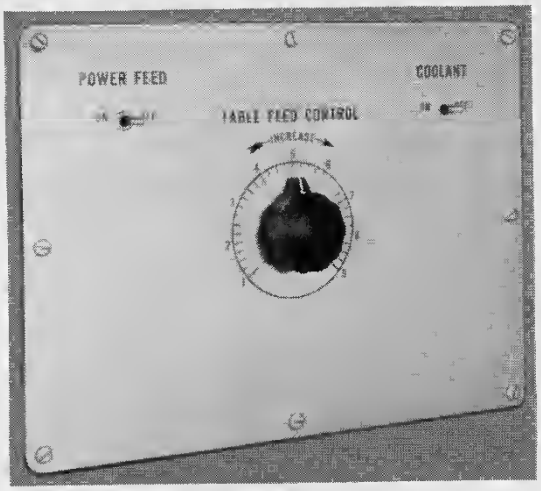


Figure 131A
Electrical Controls at Front of Machine

Cutting Fluid. Shown in Figure 131A, in the upper right hand corner, is the switch for starting the cutting fluid pump motor to supply cutting fluid to the grinding action.

Power Table Traverse. The power feed mechanism operates through a selenium rectifier that supplies power to the dc motor drive. The delivered voltage is varied by a powerstat unit to produce infinitely variable feeds to table from 7″ to 90″ per minute. The table traverse motor start-stop switch (POWER FEED) is located in the upper left hand corner of the control panel on front of machine while the powerstat control switch (TABLE FEED CONTROL) is mounted in the center of the plate (Figure 131A).

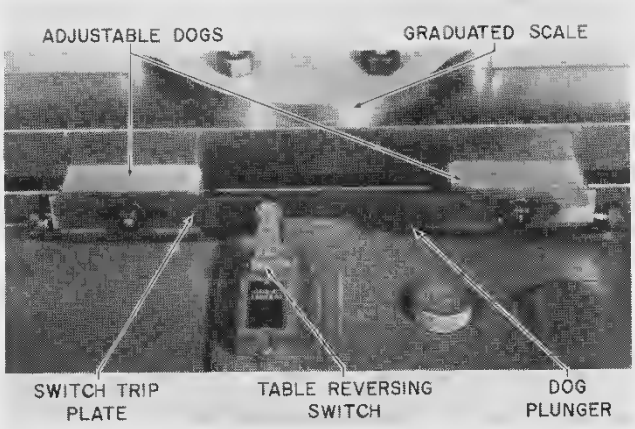


Figure 132A
Close-up of Table Dogs

Table Dogs. When the switch trip plates are clamped in outermost position, a spring behind the plunger extending from the dog absorbs the shock at the end of the stroke, and helps reverse the direction of table motion. This is the normal setting of the trip plate and dog for the majority of cutter sharpening operations.

If a solid stop is desired, the dogs can be reversed and the trip plate retracted or removed. The knurled head of the adjusting screw then contacts the table stop.

Disengage Lever. Disengage the power traverse by swinging the pinion disengaging lever to the rear position as shown in Figure 132B. Make the necessary job set-up by using manual controls, then disengage hand knobs from table rack before engaging power feed.

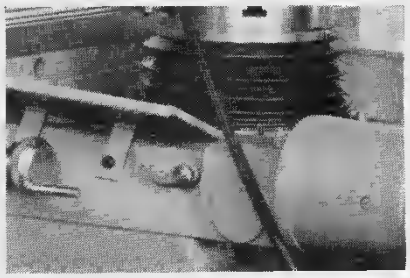


Figure 132B
Disengage Lever

ATTACHMENTS

Precision Universal Headstock. This attachment is very useful for precision cylindrical grinding. The live or dead center headstock makes it possible to select the correct surface speed for various work diameters by providing infinitely variable speeds. This headstock swivels 360°, swings 12″ diameter work; live or dead headstock center; infinitely variable speeds range up to 400 rpm; No. 5 American Standard Spindle Nose with a choice of No. 7 B. & S., No. 9 B. & S., No. 12 B. & S., or No. 5 Morse Taper; ¼ hp, totally enclosed, reversal motor and special right-hand tailstock with retractable center.

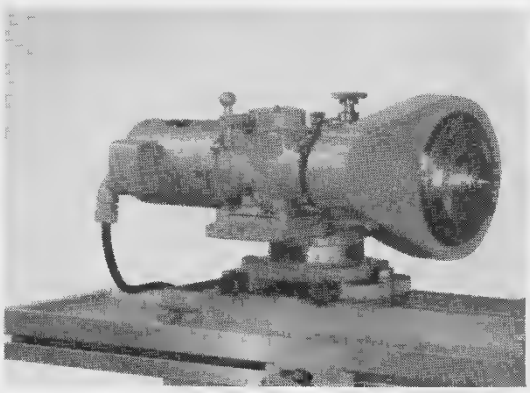


Figure 133A
Precision Universal Headstock

Cutting Fluid Attachment. This unit supplies cutting fluid to the grinding action on jobs where better finishes are desired. Also reduces heat, preventing any tendency to anneal the work surface. This attachment includes pump, capacity 5 gallons per minute; 1/10 hp motor; piping and splash guards.

Note: For Standard Equipment Supplied and Extra Cost Equipment available for Plain and Universal Machines, see Pages 8 and 9, 116 to 122 inclusive.

Figure 133B
Cutting Fluid
Attachment

ORDERING REPAIR PARTS

You will receive quicker service when ordering repair parts if you will adhere to the following procedure:

1. **State amount wanted.**

2. **Give part number and name or description of part, and where obtained.**

   (a) Part number stamped on part.

   (b) Prior invoice.

3. **Give complete serial number of machine.** This number will be found stamped on the front of the bed, below the name CINCINNATI

4. **Specify each individual piece required.** If only certain parts of a unit are required, never use the word "complete"; it always raises the question as to how much of the unit to supply. In some cases, due to the nature of the parts, it will be less costly to you for us to supply additional related pieces, especially if part wanted is obsolete.

5. **Specify how and where to ship.** Do not say "Ship quickest way". Be definite and state the agency desired, that is:—Air Mail, Parcel Post, Special Delivery, Express, Motor Freight, Rail Freight, etc.

ALPHABETICAL INDEX

ALPHABETICAL INDEX—Continued

ALPHABETICAL INDEX—Concluded

MEMORANDUM

MEMORANDUM

MILLING MACHINE DIVISION / THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO 45209 U.S.A.

MILLING MACHINES

horizontal knee & column

vertical knee & column

horizontal & vertical bed type

rise & fall and tracer controlled bed type

DIE SINKING MACHINES

horizontal

vertical

CUTTER SHARPENING MACHINES

nos. 1 & 2

monoset

Products of the Milling Machine Division of The Cincinnati Milling Machine Co. are listed and symbolized above.

Products of The Cincinnati Milling Machine Co.'s other divisions include a complete line of centertype grinding machines, centerless grinding machines, roll grinding machines, chucking grinding machines, micro-centric grinding machines, special grinding machines, metal forming machines, electrical machining equipment, special broaching machines, special machine tools and complete production lines, special machinery, numerical control systems, tracing systems, gaging systems, hydraulic motors, hydraulic and electro-hydraulic valves and components, service parts, cutting fluids and precision grinding wheels.

CINCINNATI

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